UNITED STATES DISTRICT COURT
FOR THE WESTERN DISTRICT OF NORTH CAROLINA
ASHEVILLE DIVISION

STATE OF NORTH CAROLINA ex rel. Roy Cooper, Attorney General,	)	
Plaintiff,	)	No. 1:06-CV-20
vs.	)	VOLUME 6B (Pages 1427-1570)
TENNESSEE VALLEY AUTHORITY,	)	
Defendant.	)	

TRANSCRIPT OF TRIAL PROCEEDINGS
BEFORE THE HONORABLE LACY H. THORNBURG
UNITED STATES DISTRICT COURT JUDGE
JULY 21st, 2008

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MONDAY AFTERNOON, JULY 21, 2008

THE COURT: All right. We're ready to proceed on cross examination.

JOHN MOLENAR

CROSS EXAMINATION

BY MS. GILLEN:

Q. Good afternoon, Mr. Molenar.

You relied, I think you testified, on STI's modeling assessment for your opinions in this case.

A. Yes.

Q. And you did not run the CMAQ model yourself.

A. No, I did not.

Q. And further, you took the calculation -- STI's calculations of the changes in visual range and then put those computations into your WinHaze program to generate the images; is that correct?

A. Yes.

Q. And did you do the visual range calculations yourself or did you just take STI's calculations?

A. I just took the data from the report.

Q. You did not verify the inputs to the CMAQ model that STI used that were provided by Dr. Staudt, did you?

A. No, I did not.

Q. So it would follow, then, if Dr. Staudt's inputs to the STI models were incorrect, STI's modeling results would be

affected in some way.
A. They would be different, yes.
Q. And it would also follow from that that if STI's modeling were different, your opinion -- your visual images that you created from the WinHaze program would also be different.
A. Yes.
Q. And I just wanted to clear up something about the modeling. I think when you were testifying about the base case modeling that STI did, you referred to it as current conditions. You're aware that it was actually 2013 conditions that constituted the base case, correct?
A. I used the word current as their base case. They're interchangeable, yes.
Q. And current would be 2013 for STI.
A. Yes.
Q. Okay. And the other point I wanted to just clarify, at the end of your examination, you mentioned natural background levels. Is that the right terminology?
A. Yes.
Q. When is the last time the United States saw natural background levels for visibility?
A. Nobody knows.
Q. Why is that?
A. Because the concept of natural background is an amorphous concept that was put into the Regional Haze Rule. A lot of

effort has gone on in the last ten years to determine what those levels would have been. They were --

Q. Sir, would it be safe to assume that it would be some time before big time human development on the United States continent?

A. That's the concept behind it, yes.

Q. Great. Thank you. In your conclusions in your first expert report, you state that "under the Regional Haze Rule, states have an affirmative responsibility to implement emission reduction strategies that reduce emissions responsible for visibility impairment in Class I areas." Is that correct?

A. Yes.

Q. And the states in which TVA operates its electric coal-fired plants are governed by the Regional Haze Rule, are they not?

A. Yes.

Q. And the Regional Haze Rule also said -- the final rule, also said that "EPA has long held that normal meteorological variations should be explicitly accounted for in air quality analyses and control strategy design." Is that correct?

A. I'd have to see it, but I believe it would be, yes.

Q. And on days when it is foggy or raining, visibility is impaired by those meteorological conditions, correct?

A. For periods of that day they are, but not all day.

Q. What if it's raining all day?
A. Very seldom does it rain all day long. Even when it's raining, you have periods where you can see when the rain stops. So the concept of 24-hour averages is something that is not what you really see, experience visibility instantaneously. So an average visibility change for a day is a nice metric to use, but it does not match what a human would see if they went out to a park.
Q. Okay. But on days when -- the portions of the day when it's foggy or raining, visibility is impaired by the fog and the rain, correct?
A. Yes, it is.
Q. And STI's estimates of visibility improvements actually assumed that all days are free of meteorological obscuration to visibility, don't they?
A. Yes.
Q. So their model days of maximum improvement in visibility could be ones that were influenced by weather patterns that are typically associated with meteorologically caused visibility impairment, could they not?
A. Yes.
Q. And the WinHaze program that you developed, that only represents visibility during daylight hours; is that right?
A. Represents visibility at the time the picture was taken. For one specific time during daylight hours, yes.

Q. And base picture, the digital images that you use are usually taken during daylight hours; is that correct?
A. Yes.
Q. And they're usually taken on cloud free days, right?
A. Yes.
Q. I think you testified that there's no doubt that a two dimensional image does not match reality; is that right?
A. It does not exactly match reality, yes.
Q. And you also said in a presentation in June 2001 that you gave to the Midwest Ozone Group that seeing is a psychophysical phenomenon not easily modeled or reproduced by any process that is strictly physical in origin.
A. Yes.
Q. And photographs would be strictly physical in origin, right?
A. Yes.
Q. And perceived visual effect is dependent upon atmospheric properties like lighting of the scene, cloud cover, ambient extinction, correct?
A. Yes.
Q. And it's also dependent on seeing characteristics like the size, shape, color, texture and distance to features.
A. Yes.
Q. And it's also dependent on the observer characteristics like their age, experience, socioeconomic background, their

values; is that not true?
A. No, it's not true.
Q. It's not?
A. It's not.
Q. Oh, I believe that's a -- actually a quote from your report.
A. The perception of the changes is independent of any other cohort. The value put on that change is dependent on your background. But the perception of the change which we found in the early studies from '79 to '82 was independent of age, location, gender, anything. People see changes in visibility uniformally.
Q. Okay. If you would be so kind as to turn to Plaintiff's Exhibit 265 which has, I think, been admitted into evidence. It's your supplemental report, Page 3.
A. 265?
Q. Yes, 265. I think in that notebook it's actually denominated as your supplemental report.
A. Okay.
Q. Yeah, and it's on Page 3 in the first paragraph.
Sorry, I may have the wrong exhibit number. Well, it's -- you have it, right?
A. Yes.
Q. Okay. It's the first paragraph there. I believe you're commenting on a comment from Dr. Tombach and you say, "I agree

that human perception of changes in visual air quality is a complex function of atmospheric properties such as lighting conditions, cloud cover and ambient extinction. Seeing characteristics such as size, shape, color, texture and distance to features and observer characteristics such as age, socioeconomic background, experience, values," et cetera.

A. Yes.

Q. Thank you. And no robust model that accounts for all those variables that we just discussed really exists yet, does it?

A. No, not completely.

Q. The deciview calculation, that's a result of several simplifying assumptions.

A. The mathematics is not. The interpretation of it is, yes. The actual mathematics is a very straightforward equation.

Q. But the deciview calculation doesn't take into consideration such factors as the characteristics of the scene.

A. The rationale behind deciview was justified that in the wide variety of scenes in Class I areas, that you would find a sensitive target at the proper distance. And so that was then justified as saying that that sensitive target will experience changes, perceptible changes with a 10 percent change in visibility -- of extinction. That then saying how can we --

how can that be turned into a mathematical equation? What manipulation of extinction coefficient can we come up with that represents a 10 percent change as a uniform increment? That's why we came up with the logarithmic transformation of extinction to a new method called deciview.

Q. And at that same presentation you gave to the MOG, Midwest Ozone Group, in June 2001, you acknowledged that the WinHaze program you used to generate your images does not account for color shifts due to absorbing aerosols or gases, correct?

A. WinHaze doesn't, but the full radiative transfer model does. The reason we have WinHaze is the full radiative transfer model can take a day or more to create an image. People will not sit at their desk for a day.

Q. And the IMPROVE algorithm that you used to calculate the deciview?

A. Calculate --

Q. Sorry?

A. -- extinction?

Q. Yes.

A. Okay.

Q. That's a relatively simple estimate, I think you've characterized it as.

A. The original one was relatively simple. The second one is much more complicated.

Q. Right. Which one did you use here? The old IMPROVE or the new IMPROVE?
A. It was done by STI. I'm not sure which one they used.
Q. I think they used the old.
A. Okay.
Q. I have it on authority. And the old IMPROVE algorithm requires several assumptions, does it not?
A. Yes. They all do, yes.
Q. It assumes that the absorption by gas is at zero.
A. Yes.
Q. And it assumes that natural Rayleigh scattering is 10 inverse megameters regardless of the elevation.
A. Yes.
Q. And it assumes that natural Rayleigh scattering is 10 inverse megameters regardless of temperature and barometric pressure.
A. Yes.
Q. You testified here today and in your report you said that one deciview is considered to be a perceptible scenic change under many circumstances, right?
A. Yes.
Q. So not all circumstances.
A. That's right, yes.
Q. And Dr. Henry's studies show you need a larger than 1 deciview change to be perceptible, right?

A. No. He said there was a probability of detection which is different than saying it has to be larger than 1. He said specifically that between 17 and 35 percent of the populous would see a 1 deciview change.
Q. So that would leave 65 percent of the population wouldn't.
A. If you accept his average variability.
Q. Right, we're accepting. I'm just asking you about Dr. Henry's results.
A. Yes.
Q. Okay. And you said that Dr. Henry's experiments were well done.
A. Yes, his experiments were well done. He's a very good researcher.
Q. And Dr. Henry's studies have advanced the understanding of human perception of visual air quality.
A. Yes.
Q. And in its final Regional Haze Rule, EPA acknowledged that for some types of scenes with other site specific conditions, for instance, where the site path to a scenic feature is less than the maximum visual range, a change of more than 1 deciview might be required in order for the change to be perceptible. And they further said a 1 deciview change may not be their threshold of perception in all situations.
A. Yes.

Q. You were talking about the federal land managers.
A. Yes.
Q. And their responsibility is to assess potential impacts on visibility for new sources.
A. Yes.
Q. Correct?
Not existing sources such as the ones that TVA operates in the three-state region.
A. Exactly, right.
Q. Let me refer you to what was admitted into evidence as Plaintiff's Exhibit 160. I think it's in your notebook.
A. 160?
Q. 160.
A. I don't have 160 here.
Q. I think, it's in the notebook that Mr. Goodstein gave you, isn't it?
A. No, I don't have -- oh, I see it. Sorry.
Q. That's okay.
A. I'm sorry. Yes. Yes. Yes.
Q. That's the problem with the low tech version.
So you got it?
A. Yes, I do. I have it right here.
Q. Okay. I just wanted to confirm that these are maximum impacts on specific days, right, that STI has in this chart?
A. Yes.

Q. Okay. So they're not averages over the 20 percent haziest days.
A. No.
Q. So this is the absolute maximum worst?
A. Maximum model improvement.
Q. And if I could now turn your attention to Plaintiff's Exhibit 302 which is also in that notebook.
A. Yes.
Q. And this is a chart you generated translating STI's calculations of visibility impact in terms of visual range and you then translated it into delta deciview changes; is that right?
A. Yes.
Q. And then that last column on the right-hand side where -- which is entitled Number of 20 Percent Haziest Days with a Delta Deciview of Greater Than 1.
A. Yes.
Q. The figures in that column, it shows an aggregate number of those days, but it doesn't actually show a distribution of the values for those days, does it?
A. No, it doesn't.
Q. Right. So it's possible that that first column where it says there's 18 days with a delta deciview over 1, all 18 could be 1.1. We can't tell from this chart, can we?
A. Well, we know at least one of them is 7.

Q. Excuse me?
A. We know at least one of them is 7, so the other 17 could be 1.1, yes.
Q. Okay. Taking out that 7. But this chart wouldn't tell us anything about the range of values within that aggregate number.
A. No, it does not.
Q. Okay.
MS. GILLEN: Just give me one minute, please.
(Pause.)
BY MS. GILLEN:
Q. So you testified that you are familiar with Dr. Tombach's results -- reports in this case, right?
A. Yes.
Q. And you're aware that what he -- one of the things he evaluated was the difference in visibility impacts from TVA's plants from what TVA modeling predicts the world will be like in 2013 with all of the controls that TVA projects to be putting on its plants, and compared that to what the world would be like if TVA put on the controls that North Carolina asks it to in this case. Is that your understanding of what he looked at, one of the things he looked at?
A. Yes.
Q. And I want you to assume for a moment -- this is an assumption -- that the world will be as TVA predicts it will

be in 2013. And I'm going to show you a chart from Tombach's report that gives the values for what he calculated as the delta deciview between what he called the TVA control case and the Clean Smokestacks Act control case. Are you familiar with this chart?

A. Yes, I am.

Q. Okay. The top of this is the difference in visibility impact over the worst 20 percent of the days. Can you tell us what that shows. Assuming, just assuming, taking it at face value.

A. Those are all separate receptor areas? That's what that -- yeah. And that would be the average for each receptor of the visibility impacts modeled by TVA, and they're all, except for four of them, less than .1 deciview.

Q. Which is the threshold that you consider to be, quote, unquote, significant, 1 deciview.

A. Yeah, it's .1.

Q. .1.

A. Yes.

Q. Oh, I'm sorry. It's a tenth. Forgive me. It's a tenth of the threshold that you consider significant, correct?

A. Yes.

Q. And then on the bottom chart, what does that show?

A. That's on the best 20 percent days, the cleanest days?

Q. Right.

A. And it shows that all except one day is below .05.

Q. So assuming that the world will be as TVA predicts it will be in 2013, all of the values will be significantly lower than the threshold that you consider to be significant, the 1 deciview.

A. The data on this would say that, yes.

MS. GILLEN: Thank you so much, Mr. Molenar.

I have no further questions, Your Honor.

THE COURT: All right, Ms. Gillen. That will -- any further questions?

MR. GOODSTEIN: May I have a moment, Your Honor, please?

(Co-counsel conferred.)

REDIRECT EXAMINATION

BY MR. GOODSTEIN:

Q. Mr. Molenar, the data that you were just shown from Dr. Tombach's report, had you reviewed that previously?

A. Yes, I reviewed Dr. Tombach's report. And then I reviewed STI's supplemental report which said that Dr. Tombach's report on the TVA modeling was inaccurate and that their modeling modeled changes which were much higher was accurate.

Q. So did this report, this supplemental report by Dr. Tombach change your conclusions in any way?

A. No, because of the fact that I believed that the STI

modeling results appeared to be more valid.

MR. GOODSTEIN: Nothing further for North Carolina.

THE COURT: Ms. Gillen?

MS. GILLEN: Oh, I'm sorry. Nothing further, Your Honor.

THE COURT: All right. That concludes this witness?

MR. GOODSTEIN: Yes.

THE COURT: All right. Thank you. And that will complete your testimony. You may be excused.

THE WITNESS: Thank you.

(Witness stepped down.)

MR. GOODSTEIN: Our next witness is Dr. Charles Driscoll.

THE COURT: All right.

CHARLES THURSTON DRISCOLL, JR.,

being first duly sworn, was examined and testified as follows:

MR. GOODSTEIN: May I approach, Your Honor? We have a binder for you for Dr. Driscoll.

(The document was tendered to the court.)

DIRECT EXAMINATION

BY MR. GOODSTEIN:

Q. Good afternoon, Dr. Driscoll.
A. Good afternoon.
Q. Can you state your full name for the record, please.
A. Charles Thurston Driscoll, Jr.

Q. And how are you currently employed, Dr. Driscoll?
A. I'm a professor in the Department of Civil and Environmental Engineering at Syracuse University.
MR. FINE: In the interest of hopefully continuing to move things along, Your Honor, we have entered into a stipulation as to Dr. Driscoll's expertise as set out in the plaintiff's submission of proposed credentials for their experts. I believe that Dr. Driscoll's expertise is in environmental engineering with a focus on effects to ecosystems from air pollution.
THE COURT: All right. Let the record show the stipulation, and I believe that is as appears in Plaintiff's Exhibit 432?
MR. GOODSTEIN: That's right, Your Honor. That's Dr. Driscoll's CV. And we'll tender him at this time in environmental engineering with a concentration on air pollution effects on ecosystems.
THE COURT: All right.
BY MR. GOODSTEIN:
Q. All right. So what -- how would you describe your area of expertise, Dr. Driscoll? We've done our best.
A. Okay.
Q. Why don't you tell us.
A. As I said, I'm on the faculty in the Department of Civil and Environmental Engineering at Syracuse University. I do

research and teach classes in environmental impacts, engineering applications of those -- of those impacts. And a focus of my research activity has been on air pollution effects on ecosystems.

Q. And how are you involved in this case?

A. I was contacted by the attorney general's office of the State of North Carolina a couple of years ago to provide a review of scientific literature of impacts of acidic deposition of mercury on ecosystems in forests, aquatic ecosystems, coastal ecosystems. I evaluated the state-of-the-science concerning those effects, and I also specifically evaluated the contribution of Tennessee Valley Authority emissions on deposition, and evaluated how improvements in deposition might occur under the scenario of controls that were sought by the State of North Carolina in this case.

Q. Did you also look at mercury deposition?

A. I did look at mercury deposition and effects of mercury on ecosystems, that's correct.

Q. And what were the main ecological effects that you looked at?

A. Okay. I evaluated the current state of atmospheric deposition of sulfate and nitrate and mercury.

I evaluated how it's changed in the recent past in response to controls on emissions.

I evaluated spatial patterns in the components of deposition.

I evaluated the effects of acidic deposition on soils and then subsequent impacts on red spruce.

I evaluated the effects of acidic deposition on fresh water chemistry and those impacts on aquatic organisms within the region.

I evaluated the impacts of mercury deposition on the region and the interactions between atmospheric mercury deposition and sulfur deposition.

And I finally evaluated the impacts of nitrogen inputs to coastal resources within the region and the effects of reductions in nitrate deposition to those coastal resources.

Q. And Plaintiff's Exhibit 432 for identification, is that a copy of your CV?

A. It is, but it's two years old.

Q. Can you give us whatever -- in summary form whatever updates you have for your CV since this one is the version that you submitted with your report in this case.

A. I periodically update my resume, so as additional -- I have additional publications or additional projects or additional presentations, I've added -- I've added those in. So there's been some activity in the last couple years.

Q. So approximately how much additional publications?

A. Maybe 20, 25 additional publications, maybe 5 to 8

additional research grants, maybe 40 presentations to audiences.

Q. And have you also been inducted into the National Academy of Engineers --

A. Yes.

Q. -- since this CV was prepared?

A. Yeah. Last year I was selected and inducted into the National Academy of Engineers.

Q. Can you tell us a little about that recognition.

A. It's a great honor. It was unexpected so it's -- what's involved is you're nominated by someone in the academy and then you're evaluated by the individuals in the academy and then ultimately voted on, and you have to receive a certain number of votes in order to be inducted. They induct about 30 -- or excuse me, 60 people per year, so...

Q. And then what activities are you involved in at the National Academy of Engineers once inducted?

A. Well, you become involved in processes of nomination of individuals. They also strongly encourage you to participate in various technical reviews, various committees that are done by the National Academy, but also through the National Research Council. So I've just recently finished up one on the everglades that I've been involved in for the last two years, and I've done several in the past as well.

Q. Can you describe for us your educational background,

please, and I believe it's summarized on Page 1 of your CV.

A. Yes. I received my Bachelor's in Civil Engineering from the University of Maine in 1974. And I completed my Master's in Environmental Engineering at Cornell in 1976 and my Ph.D also at Cornell in 1980.

Q. And what was the topic of your dissertation?

A. Well, I worked on mercury -- or excuse me, not mercury, aluminum in acidic waters in the Adirondacks. The Adirondacks, which is a large park in upstate New York, receives high inputs of acid rain. And at the time there was interest in observations of aluminum. So I evaluated the mobilization of aluminum by acid rain. I looked at -- I developed some methodologies to evaluate different forms of aluminum that occur in waters and what the toxicity of those would be to fish.

Q. So you've been looking at these issues for a number of years.

A. Approximately 30 years.

Q. And in your current position as a professor of environmental systems engineering at Syracuse University, can you tell us what courses you're teaching and what are your other duties in that position.

A. Yes. So I teach -- the courses I teach vary somewhat from year to year, but generally I teach a junior level course in introduction to environmental engineering. So we deal with

different quantitative approaches to environmental problems, air problems, solid waste problems, water treatment, water -- drinking water supply treatment and waste water treatment.

I am in the process of developing a new course in sustainable engineering which will be taught starting next year to sophomores.

I teach a course in the fall semester which is titled biogeochemistry and that deals with sort of large scale issues concerning pollutants of major elements. So things like carbon, nitrogen, sulfur, phosphorus and mercury. We deal with the entire issue including atmospheric impacts, soil impacts and surface water impacts. That course is taught for both undergraduate and graduate students.

In the fall I teach a class in environmental modeling which is primarily taking my graduate students, although I occasionally get a few undergraduates that are ambitious in that class.

And then I teach a seminar course on -- paper reading course on different environmental topics.

Q. And what departments are you a member of at Syracuse?

A. I have affiliations with the Departments of Biology, Chemistry, Earth Sciences. And my principal appointment, as I said, is in the Department of Civil and Environmental Engineering.

Q. And what is the Center for Environmental Systems

Engineering?

A. That is a -- that's a center, a location within a building where there are housed research facilities for approximately 9 faculty and approximately 40 graduate students. There's also a number of undergraduate students that are associated with that. And they are largely experimental facilities and computing facilities for inter-disciplinary environmental studies and projects. So the faculty who have space are within engineering, but we have a lot of folks from other departments in the university as well as from other universities that come in and use our facilities. We also have a lot of students come in from other institutions that use our facilities.

Q. Okay. And in your work and in the courses that you teach, do you regularly deal with air quality modeling and interpretation of modeling results?

A. Yes. So I mentioned this introductory environmental engineering course. We talk about air quality issues and assessment of air through the use of models, the variety of modeling approaches that are used. And in the biogeochemistry class we do talk about air transport models and how they are used and how data are interpreted from those models.

Q. And are you on any boards that you deal with issues of air pollution effects on ecosystems?

A. I'm on two boards. One is the Upstate Fresh Water

Institute which is a not-for-profit research institute largely focused on fresh water resources in upstate New York. They primarily look at issues of nutrients in water quality, mercury to a lesser extent.

The other board I'm on is the Hubbard Brook Research Foundation which is a friends group for the Hubbard Brook Ecosystem study, which is a long-term ecological study funded primarily through the National Science Foundation. There's actually a long-term ecological research station quite near here, the Coweeta Hydrological Laboratory, a few miles from here. This friends group helps provide support for housing, educational activities, outreach activities for the investigators at the site. There are approximately 20 institutions that are involved, including the local university here. And probably about 70 investigators and students work at this site. It's one of the longest running ecological study sites. It was established in the '50s so it's been going for a long time.

Q. And can you describe for us, summarize for us the research that you're engaged in, and I believe these are -- some of your research projects are summarized at 111 to 115 of your CV.

A. Yeah. A significant fraction of my activity is research activities in addition to my teaching. So the process generally involves writing proposals to different agencies,

mostly funding -- federal agencies, excuse me, for funding. Most of my funding comes from unsolicited sources such as the National Science Foundation, Environmental Protection Agency. We've gotten some funding recently from the USDA. So a few competitive grants programs.

I work on a variety of problems, but I'd say probably maybe two-thirds of my work, three-quarters is focused on air pollution effects of ecosystems, so that would include acid rain effects on soils and surface waters. It would include effects of mercury in terms of mercury deposition and transformations of mercury within ecosystems and also nitrogen enrichment to coastal waters.

I use a variety of approaches as a researcher. I do a lot of field work. I would say probably two-thirds of my work is field based. So we go out, we instrument sites. We do collections of sites. We do long-term measurements. We do repeated measurements of stream water and surface waters and soils to look at long-term patterns. We do experiments. And the Hubbard Brook experimental forest that I mentioned previously is a great place to work because it's a Forest Service experimental forest so it allows the researchers to do actual manipulations of experiments -- of ecosystems.

So to give you an idea, a couple years ago we applied calcium to a watershed with a helicopter to try to depict what would happen to replace the calcium that we felt was lost from

60 years of acid rain in the region. So we used a very unique form of calcium which had tracer capabilities so we can track where that calcium can go into soil, into vegetation, which species of vegetation take it up, what parts of the vegetation it goes into, how much is lost. And this is actually designed as a 50-year experiment.

So with this type of research, the processes are long term so we design experiments as long-term operations.

I also do modeling. I do watershed modeling for effects of climate change and air pollution as well.

So we use a variety of approaches to try to address questions we have concerning ecosystem pattern and processes.

Q. Approximately how many field studies on air pollution impacts to ecosystems have you been involved in, Dr. Driscoll?

A. I've had approximately 80 funded research projects, and probably three-quarters of those address air pollution impacts on ecosystems.

Q. Could you summarize your publications which are listed on 85 to 102 in your CV, Plaintiff's Exhibit 432.

A. Sure. So being an academic, a researcher, an important objective is to try to communicate results of research to peers and also to managers, I should add. So we aggressively try to write up the results of our work for peer-reviewed publications.

So when we complete a study, we will typically write it

up, submit it to a journal for peer review; and then we get comments back and then we resubmit it. If we're fortunate enough, it's ultimately published. So we try to do this with projects. I think it's quite important -- we get our funding largely from tax dollars and it's important that the information get out to people so this information can be used.

Q. And approximately how many publications do you have?

A. A few more than 300.

Q. And these are peer-reviewed journal articles?

A. Yeah, all peer-reviewed articles.

Q. All right. And your writing also includes some book chapters including one on the southeast?

A. Yes. So some book chapters and also we've done some books and so these are summaries of research results. And a few years ago I was involved in a synthesis of acid rain effects on soils in the southeast and that was published as a book.

Q. And so that's listed as the first book on page 85 of your CV?

A. That's correct.

Q. Do some of your publications in peer review journals deal with acidification and mercury pollution?

A. Yes. I would say maybe three-quarters either deal with acid rain effects on ecosystems or mercury effects or the linkage between mercury and acid rain. So that's been a major

focus of our research program, so there's quite a bit of -- quite a few publications on that.

Q. And you serve on a number of national committees.

A. Yes. As I said, I've been involved in the National Academy and National Research Council committees. I mentioned previously the one that's just winding down in the everglades. Prior to that I was on a very interesting committee. The title of it was called Air Quality Management. We reviewed the Clean Air Act, how -- its successes and failures, and made recommendations for how it might be restructured in the future.

I've been on other -- or I am on other committees. I just finished up a committee with the Hines Center which tracks the state of the nation's ecosystems. I was on the air quality working group. That book was just released a few weeks ago.

I'm currently on CASAC which stands for Clean Air...

Q. Scientific --

A. Science Advisory Committee, thank you, and we're in the middle of evaluating programs to evaluate secondary effects of air pollutants and its effects on ecosystems. So I'm right in the middle of that process now.

Those are a few of them.

Q. And can you summarize your prior testimony for us on air pollution effects on ecosystems.

A. Yes. I've been fortunate enough, I was able to provide some testimony to Senate and House committees on air pollution effects. I've also been able to participate in state legislature committee hearings. I was also in a court hearing a number of years ago for the State of Minnesota on an air pollution case for that state.

Q. Okay. And can you summarize for us your awards and honors. You've mentioned one of them, the National Academy. And I believe these are summarized on Page 84 of your CV, but if you could just give us an overview, please, of the recognition you received.

A. Okay. So you -- we talked a little bit about the National Academy of Engineering. That's a great honor.

I was very fortunate early in my career, I was designated as a Presidential Investigator and that was also a great honor and a great opportunity for me. With that award research funds were provided, so that greatly accelerated my early research program, and a lot of that funding was directed towards my early acid rain research.

I have been designated by the Institute for Scientific Information, which is a service that tracks published reports, as a Highly Cited Researcher, and I was given that designation for two categories, environmental science and engineering.

So those are a few -- few awards.

Q. All right. And what was the question that you were asked

to look at on behalf of North Carolina in this case?

A. The question I was asked to look at was what are the impacts, regional impacts of acidic deposition of mercury. And specifically, what are Tennessee Valley Authority's contributions to these impacts?

Q. And also, the benefits that would result from the emissions reductions sought by North Carolina?

A. Yes. I did an evaluation of what we refer to as a base case which would be the emissions in 2013 in the absence of any additional controls on TVA facilities given the situation that North Carolina has indicated and compared that with those levels of controls that are sought by the State of North Carolina and see what the improvements in terms of deposition are.

Q. And what were your overall conclusions?

A. I was -- I was -- well, first of all, the region receives very high inputs of acidic deposition. It's among the highest if not the highest in North America.

The proposed controls that are sought by the State of North Carolina on TVA facilities produced substantial reductions in deposition. I was a little surprised at how high they were. They ranged from maybe 4 percent in the northern part of the region. The region that I studied extends up into West Virginia, to Virginia, down to the lower part of the Southern Appalachian Mountain Initiative in the

states of Alabama and Georgia and South Carolina.

So closer down to this region, the values in Kentucky and in Tennessee and North Carolina ranged from 8 percent up to upwards of 20 percent reductions in sulfate.

The levels for reductions of nitrate were somewhat less than that, on the order of a little less than 2 percent in the highest impacted areas down to about .3 percent reduction in nitrate in the lowest areas.

I also looked at impacts on forest soils and impacts on red spruce of acidic deposition. I also looked at the impacts of acidic deposition on regional aquatic resources in terms of a chemical response of these systems to acidic deposition and how organisms would respond to these impacts.

I also examined the effects of controls on TVA facilities for mercury and evaluated mercury deposition to the area and discussed the impacts of mercury on regional resources.

I also addressed the interactions between mercury and sulfur because the -- sulfur has an important component of the mercury cycling process. So there's some interactions there.

And then finally, I addressed the impacts on coastal waters.

MR. FINE: Your Honor, for the record, I'm very mindful of Your Honor's prior rulings on this subject. We would like to note for the record an objection to any testimony from Dr. Driscoll concerning sulfate deposition and

its effects.

THE COURT: All right. Let the record show the objection, and the court's ruling is overruled.

Q. Dr. Driscoll, the recent vacating of the CAIR rule, is that potentially going to have an impact on the estimates of nitrate deposition that you used in your analysis?

A. I believe it would. I believe the assumptions that were made in the analysis were that the facilities would implement year-round controls associated with the Clean Air Interstate Rule. And given that that's vacated, the estimates that I showed in my report are likely an underestimate of the nitrate deposition because there would no longer be requirements for year-round controls of nitrogen oxide emissions.

Q. And have you prepared several reports summarizing your conclusions in this case?

A. Yes, I have.

Q. And are they at the back of your notebook? They should be marked for identification as Plaintiff's Exhibits 474, 475 and 476.

A. Yes.

Q. Could you take a moment and just make sure those are true and correct copies of your reports.

A. Yes, those numbers are correct.

MR. GOODSTEIN: At this time, Your Honor, we'll offer 432, which is Dr. Driscoll's CV, and then 474, 475 and

476 into evidence, which are Dr. Driscoll's reports.

THE COURT: All right. Let those be admitted.

(Plaintiff's Exhibits Numbers 432, 474, 475 and 476 were received into evidence.)

Q. Turning your attention to Plaintiff's Exhibit 474 for identification. It should be the next exhibit in your book. Is this a figure out of your book which describes the area, the sensitive areas that you looked at with regard to acidic deposition?

A. Yes. This is a map indicating the Southern Appalachian Mountain Initiative or SAMI study region, and this is an area focused in my report. I did include other literature from other areas in the U.S. and Europe as need be, but the focus was on the southeast, so the -- I tried to focus on the areas shown here.

Q. And what does this figure show?

A. Well, this is a map of a multi-state area extending from Alabama up to Virginia and West Virginia.

Within the area indicated in white, that's the SAMI region. There is, within there, a green area and that represents a certain type of bedrock, silicaceous bedrock, which is the most sensitive bedrock type and generally shows the greatest effects of acidic deposition. There are three major bedrock types in the region: Silicaceous, as I've shown here. That's the most sensitive. Granitic, which is of

intermediate sensitivity, but still pretty sensitive, and basaltic. And so the white area represents those other two.

Also shown are little dots and those represent stream sampling sites, and there are two colors, yellow and orange, and both those values are relatively low values of a measurement that's known as acid neutralizing capacity. Acid neutralizing capacity is an important indicator of the acid base status of waters.

And so you can see that generally these dots with the yellow color or orange color coincide with the green area just indicating that that bedrock geology is particularly sensitive, the landscape around that bedrock geology is particularly sensitive to acidic deposition.

Q. And you also have a figure in your report that identifies the wilderness areas that are on national parks that are within this sensitive mountain ecosystem.

A. Yes. I think one great thing about this region is there is fabulous resources: A number of national parks, Class I wilderness areas, national forests. So those are resources of particular concern and so I've indicated that on this map.

I also did some analysis on Pamlico Sound and that's shaded as well.

Q. Okay. So you're referring to Plaintiff's Exhibit 321 for identification?

A. Yes. I'm sorry.

MR. GOODSTEIN: Your Honor, if I could approach, I'd like to put the large size of this up on the easel so that Dr. Driscoll can refer to it during his testimony.

THE COURT: All right. You may do so.

MR. GOODSTEIN: Thank you, Your Honor.

Q. All right. Dr. Driscoll, can you explain to us what this shows, Plaintiff's Exhibit 321.

A. Yes. This is a map of the multi-state area, including the area that I addressed in my expert report. And what's indicated on the map are -- in the yellowish or orangish colors are the various national forests, national parks, and also in numbers the Class I wilderness areas in the region. And then in yellow, I mentioned that I also did some analysis on the impacts of nitrogen in Pamlico Sound so I've got that Pamlico Sound watershed shaded on the map as well.

Q. And can you tell us, give us a little background -- I know you're familiar with the testimony of Bill Jackson from the U.S. Forest Service in the trial earlier so we don't want to go over any ground that Mr. Jackson went over, but can you just give us an overview of the aspects of acidic deposition that you considered for your analysis.

A. Yes. So the aspects I considered in my report were deposition, including different types of deposition.

I include -- I also evaluated impacts of acidic deposition on soils and red spruce vegetation.

I also looked at impacts on surface waters, including the chemical effects and the associated biological impacts.

I also looked at mercury deposition and its effects on ecosystems.

And then finally, I looked at inputs of nitrogen to coastal waters.

Q. You had a figure in your report that summarized the process that leads to wet and dry deposition.

A. Yes, I have a conceptual diagram. I think it's Exhibit 157.

Q. All right. So referring your attention to that, can you summarize for us how emissions from sources like TVA's coal-fired power plants result in acidic deposition.

A. Yes. So the focus here is on emissions of sulfur dioxide, nitrogen oxide and mercury. And these can occur naturally, but they also can occur due to human -- human impacts and that's largely associated with fossil fuel combustion.

So these materials are emitted into the atmosphere. There are transformations that occur within the atmosphere and then they're ultimately deposited to the earth's surface.

There are three pathways, three principal pathways of deposition to the earth's surface.

The easiest pathway to determine is what is known as wet deposition and that's the quantity of these materials that are

deposited in precipitation, rain or snow. So this is the quantity of material that's deposited per unit land area per unit time. And it's often expressed in units of kilograms per hectare per year. The scientists usually use that unit.

The second component is what is known as dry deposition and that refers to the impacts of gases or particles to the land's surface.

And then the final component, which is not terribly important in most areas, but it's quite important in this area because of the high elevation, and that's cloud deposition. So in the very high elevation areas that are immersed in clouds for a large percentage of the time can receive a substantial amount of their total deposition via cloud water.

Q. And did you look at the output of the CMAQ modeling runs that STI did in your analysis of acidic deposition in this case?

A. I did. And I think there's a visual...

Q. Okay. So I'm going to refer you to Plaintiff's Exhibit 158 in evidence and ask you to describe what data from these summaries you considered in your analysis.

A. Okay. So these are output from CMAQ predictions for -- if we focus on the -- if we focus on the panel on the left, this is the so-called base case which is the 2013 condition. And this area shows the sulfate deposition, annual sulfate deposition from all these sources that I just mentioned for

the southeast region.

And if you -- if you notice, along the left-hand side there is a scale which is color coded which indicates the level of deposition. So the highest depositions are in purple and the lowest depositions are in green. So these, again, are in the same units that I referred to, kilograms of sulfur per hectare per year. So the values in purple are above 20.

So to try to -- to try to put this in perspective, scientists have estimated what background deposition is, and a good approximate estimate of background deposition would be something on the order of 1.5 kilograms per hectare.

So if you look at the scale -- I'm going to try to do this with my finger. I don't know how good I'm going to be. It's right around -- whoops. Right around there. Probably off a little bit. So in the lower part of the green bar. So you can see that the southeast is immersed in high elevated sulfate deposition.

And among the highest values are in the study areas that we've talked about, you know, the states like Alabama and Tennessee and Kentucky, North Carolina, Virginia, West Virginia, the study area that I focused on for this report.

Q. I want to show you Plaintiff's Exhibit 159 in evidence and ask you to summarize for us what data in these CMAQ outputs you considered in your analysis.

A. Yes. Again, these were outputs from CMAQ that were

conducted by Sonoma Technologies, but in the previous slide that was sulfur deposition. This is nitrate deposition.

Again, there is the scale along the side. Again, the purple colors represent the highest deposition. The green colors represent the lowest deposition.

Again, I'll try to put this on here to give you an idea of the background values. Scientists estimate that a good background value for deposition prior to human activity would be on the order of .3 kilograms of nitrogen per hectare per year. So maybe down where I've indicated here in the green bar.

So again, the whole area, the whole southeast is receiving elevated deposition. And among the highest deposition, the red colors and the purple colors, are, again, in the study area, states like Alabama, Tennessee, South Carolina, North Carolina, Kentucky, Virginia, West Virginia, the area that I focused on for my analysis.

Q. And did you also look at the NADP data on deposition for the area?

A. I did.

Q. And what is the NADP data?

A. Okay. NADP stands for National Atmospheric Deposition Program. It's a network of stations for measuring one of the components that we talked about of acidic deposition, wet deposition. And there are about 200 sites nationally. It's

run by federal agencies, state agencies, universities, research institutions. So they man these individual stations.

The network has been in existence since the late '70s so it's been around a long time. It's a long-term record. The protocols are identical across all these stations. There's common procedures for collection. The samples are collected the same day of the week, the same way. The samples are collected and shipped to a central lab in Illinois. They're all run by the same lab and they're all reported in a central database, the NADP database. It's a public access database. It's a great resource for this type of analysis.

So within this general region that I've been talking about, there were 16 stations that were either in or nearby that I focused my analysis using these NADP data.

Q. And there's a table in your report that summarizes NADP data that you looked at?

A. Yes. Yes.

Q. All right. Refer your attention to Plaintiff's Exhibit 323 for identification. Is that the table?

A. That is the table. So this is to give you a background of the wet deposition of sulfate and nitrate for this region. So I've got the name of the site on the left and then you can see the state in the second column and then the third column is sulfur deposition and then in the column next to this is nitrate deposition. And these are the average annual

deposition for a three-year period: 2002, 2003 and 2004.

So there's a range of wet deposition of sulfate. So the lowest values are about 4 kilograms per hectare per year. The higher values are down towards the southern sites such as Walker Branch Watershed in Tennessee or the Great Smoky Mountains or Mt. Mitchell near here, and those values are on the order of 5, 6, 7, up to 9 kilograms of sulfur per hectare per year.

The nitrate depositions range from low values of about 1.8 in northern Virginia to, again, higher values -- again, there's some high values in West Virginia, but there are also high values down here, again, in sites in Kentucky, Tennessee and North Carolina.

I also included some coastal systems, so coastal systems near the coast of North Carolina received inputs on the order of a little less or a little over 2 kilograms of nitrogen as nitrate per hectare per year -- kilograms of nitrogen for nitrate deposition.

Q. And how do these levels of sulfur and nitrate deposition from the NADP database compare to the background levels that you mentioned?

A. Yes. So we talked about the background levels. The background levels for sulfate, again, are about 1.5 so these are a factor of 3, 5 times higher. The background levels for nitrate are .3 so these are a factor of 5 upwards to a factor

of 10 above background levels.

Q. So what does this review of this data tell you about the wet deposition of sulfate and nitrate in the air?

A. It's high. It varies from site to site. It also varies over time, although you can't see that in this analysis, but it does vary over time. There's a lot of year-to-year variability, but there's also trends, long-term trends. So it's a great database for doing this type of analysis because there's -- it's been going around for a long time and it's all using standard procedures so you can compare across sites. So it shows elevated deposition across the region. So it's consistent with the CMAQ results that we talked about a few minutes ago.

Q. You also have a photograph in your report of the Great Smoky Mountains National Park.

A. I do.

Q. That should be Plaintiff's Exhibit 322. Can you explain to us why you included this photo in your report.

A. I put this photo in just to try to convey that this is a very heterogeneous landscape, very complex topography, and that complex topography greatly influences atmospheric deposition. So within a, you know, relatively small area like the Great Smoky Mountains National Park, there's a lot of variation in atmospheric deposition.

Q. We have in your binder, Dr. Driscoll, Plaintiff's Exhibit

176 which is in evidence and it's a certified copy of the Air Quality in the National Parks Report issued by the National Parks Service, and there was a figure in there that you wanted to refer to. I believe it's on page 37 of that document. It should be tabbed.

And does this also provide some data from the National Parks Service recording total nitrogen deposition and total sulfur deposition in the area?

A. Hopefully it does. It's not on my screen yet.

Q. Okay. You also have it in your binder, I believe, in front of you. It should be under the -- oh, it's not in your binder, okay.

A. That's fine, I can describe it if you want or...

Q. Okay.

A. Okay. This is a series of data from a study that was conducted through a program called the Integrated Forest Study. And this was a series of detailed investigations to a number of sites in North America and included a few sites in Europe looking at the inputs -- oh, here it is right here. The inputs of different materials and how they cycle through forest systems. This was funded by the Electric Power Research Institute.

So these are some summary slides for deposition. And the upper panel is for nitrogen deposition. The lower panel is for sulfur deposition. And there are a series of bars and

each of these bars represent these different study sites. And they're ordered from the highest to the lowest. So the site -- these sites -- and you can see they range from the state of Washington over to here. There's some in the northeast. There's a number in the southeast. You can see there's one in Ontario. There's one in Norway. So they're very diverse sites. But the highest site is the Great Smoky site and it has the highest sulfur and nitrogen deposition.

Why I thought this would be interesting is because I talked before about wet deposition and wet deposition represents the greenish color, the lower part of the bar. But in addition to this, this study tried to capture all sources of deposition, the three sources that we've talked about, dry deposition as well as cloud deposition. So you can see the Great Smoky site also has a substantial component of its deposition that occurs as dry deposition. But if you look at the orangish bar at the top, that's cloud deposition. And only two sites or maybe three sites had any appreciable cloud deposition, but the cloud deposition at the Smoky site was very high and that greatly elevated the total inputs to the site. So this site receives a lot of cloud water and receives very, very high inputs of deposition.

And so all three components, wet deposition, dry deposition, cloud deposition, are a significant component of total deposition for both sulfur as well as nitrogen.

Q. The caption in this National Parks Service study for these summaries says that the park experiences some of the highest atmospheric deposition levels on the North American continent. Is that something you would agree with, Dr. Driscoll?
A. Yes, definitely.
Q. Do you have a figure from your report, Dr. Driscoll, which shows the variability in deposition based on elevation?
A. Yes, I do.
Q. So I'm going to refer you to -- to 325 for identification. First identify it and then explain to us what it shows, please.
A. Yes. This is the -- this is a figure from my report. It's a very interesting study that was published a couple of years ago by Kathy Weathers and colleagues where they looked at spatial patterns across the park. They did a number of parks, but I just focused here on Great Smoky Mountains National Park.
And what they wanted to look at was this complex topography and how it influenced deposition. So you can see a map of the park and you can see that it's color coded. And the color coding refers to different levels of deposition. So the green is the lowest levels of deposition and it grades up to red with the highest levels of deposition.
So if you can remember back a couple slides ago where I

was talking about the level of wet deposition for sulfur was on the order of 7, 8, 6, 9, something like that, and nitrate deposition might be on the order of 4, or something like that. You can see that those levels of wet deposition would be within the green bar, the lowest deposition.

And if you know something about the topography of the park, you can see that the highest levels of deposition coincide with the highest elevations, and this is because of cloud deposition that we talked about previously. It's more important in high elevations. It's significant -- first of all, the levels are very, very high. As we said, among the highest in North America. It's of ecological significance because the soils in the area are very shallow and very poor in bases and they receive very, very high levels of acidic deposition and they're impacted by this deposition.

Q. And what did you consider in the relationship between changes in emissions in the region and changes in sulfate deposition?

A. Well, I mentioned a few minutes ago that one of the strengths of the NADP program is that it's been going on since the late '70s. So many of the stations have long-term records, multi-decade records of precipitation chemistry, so that allows us to track changes in net deposition with changes in emissions.

So I had an exhibit in my report to try to demonstrate

this cause and effect relationship between emissions and deposition.

Q. So I'm going to show you Plaintiff's Exhibit 326 for identification.

A. Yeah. So this is the -- this is the figure that I was talking about. So what this is is this is a plot showing emissions of sulfur dioxide for the source area to the region. That's what we call the air shed or the area where the air pollution originates. So it's a large, multi-state area which is adjacent to and downwind of these various sources.

And along the vertical scale, that's the annual sulfate deposition which is measured at these stations. So I only picked four. We have 16 so I could have done it for all 16, but that makes for a fairly confusing plot so I just picked four. I picked a site in West Virginia which was sort of at the northern reach of the study region that I looked at and then three sites in the lower region. So I took the Coweeta site that we talked about a few minutes ago that's in North Carolina and then two sites in Tennessee, including the Smoky site and Walker Branch site. And all these sites show a positive relationship between emissions of sulfur dioxide and deposition of sulfur. So what this demonstrates is that there is a cause and effect relationship between regional emissions and regional deposition.

So I've shown it for four sites, but we've done this for

a large number of sites all across eastern North America and they all show very similar patterns. The slopes may be slightly different depending on where they are, but they generally show this linear relationship where the sulfate deposition is greatest when sulfur dioxide emissions are greatest and lowest when it decreases. So there's a cause and effect relationship.

We started to do a similar analysis for nitrate, but it's a little challenging for nitrate because the emissions have not changed as much. But in recent years, through some controls that have been implemented, we're starting to see some reductions in nitrate and we're starting to see some decreases in the record. So I think the data we collect in the future, I anticipate we'll be able to see similar relationships for nitrate.

Q. So with the additional emissions reductions sought by North Carolina from TVA in this case, what change would you expect in sulfate deposition?

A. So as part of this analysis, I used the model results, the CMAQ results that we talked previously about from Sonoma Technologies, and I looked at two model outputs from CMAQ, the so-called base case in 2013 and then the control case where the controls that are sought by the State of North Carolina were eliminated from the emissions. And I looked at changes in the deposition of sulfate and nitrate for the region and

then for these individual sites that we've been talking about, these NADP sites.

Q. All right. I'll refer you to Plaintiff's Exhibit 327 for identification. And can you explain to us -- can you identify this figure and explain to us what it shows.

A. Yes. So this is in my report. And what this is is this represents the percent improvement if those controls that were sought by the State of North Carolina on TVA facilities would be implemented. And so these are -- there are various shades of blue which represent different levels of percent change.

So the darkest blues are from 46 to 15 percent reductions. This is of sulfate deposition. And this is total sulfate. And then the next shade of blue, 15 to 8; and then the next one, 8 to 4, and so on and so forth. So you can see that the greatest improvements are within the facilities immediately surrounding -- the areas immediately surrounding the TVA facilities. So in the states of Alabama, Tennessee, Kentucky, also substantial improvements in North Carolina, Virginia and West Virginia.

So these, you know, I think these are big improvements and they're focused primarily near the sources.

Q. And what did these results tell you about current impacts from TVA's excess emissions?

A. They suggest that they're very large because they range, you know, in -- you know, from, you know, somewhere 5, maybe

4, 5, up to maybe 15 percent reductions in the areas that we're talking about, these very sensitive areas. So I considered that to be a very, very large, large improvement, large change.

Q. Okay. Let me refer you, then, to Plaintiff's Exhibit 334 for identification. And can you please identify that and tell us what it shows.

A. Yes, this is a similar output from the Sonoma Technologies simulations. And again, it was plotted. Everything is identical to what I had presented previously for sulfate, but this is for nitrate.

And again, the color of the scale, you should note that the scale is different for nitrate. In the case of sulfate, it went up to 46 percent. For nitrate it goes up to about 7 percent. The darkest was from about 7 to 2 percent improvement, and then the next color from 2 to 1.

But again, you see that the benefits are largely focused around the facility. So again, the states of Alabama, Tennessee, Kentucky, North Carolina, Virginia, West Virginia. So sizable improvements in terms of reductions. And as we said, these are probably conservative estimates given the fact that CAIR was vacated recently.

Q. And what did these results tell you about current impacts from TVA's excess emissions?

A. It suggests that the excess emissions are having an

impact on nitrogen deposition on the order of, you know, 3 percent, 2 percent, somewhere in that range in these sensitive areas. I think I actually have a table in the report that I go through those specific NADP sites that we've been talking about.

Q. All right. So I'll refer you to Plaintiff's Exhibit 336 for identification. And can you identify this table and explain what it shows.

A. Yes. So this is in my report, and actually the full table is not shown here. I think there is a companion piece that goes with that that we'll talk about in a second. So these are the same 16 sites. The first 13 are mountain sites. The last three are coastal sites. So again, extending from West Virginia in the north down to Tennessee in the south.

And the two columns on the right represent the total deposition of sulfate for the first column and nitrate for the second column that are estimated from the CMAQ projections for those individual sites for 2013 under the base case scenario. So in other words, no controls.

So again, these values range from, oh, some of the northern sites are about 3 kilograms of sulfur per year and some of the higher values are up on 7 or 8 kilograms at the forest sites. And for nitrogen it ranges from about 1 or maybe a little bit less than 1 at the coastal sites up to close to 4, maybe a little less than 4 at some of the sites in

West Virginia.
Q. All right. Then there's a second page of Plaintiff's Exhibit 336 for identification.
A. Right.
Q. Can you explain to us what that shows.
A. Yes. For these same sites, these would be the improvements, the absolute and relative improvements that would be seen from the projections that were made with CMAQ for 2013 for the controls that are sought by the State of North Carolina.

So I reproduced the table. Same site name and then location. And then there's a series of four columns with numbers.

First column of numbers represents the declines in sulfate and then the column immediately to the right of that is the percent change.

So for sulfate, at some of the northern sites we would see about a 3 percent reduction from these controls. Some of the southern sites, like Mt. Mitchell, 8.4; a site in Kentucky, 13 percent control; Walker Branch, which is in Tennessee, 24 percent control; the Great Smoky Mountains, around 11 percent reductions in sulfate.

And then the last two columns on the right are the absolute values of nitrate and the change in nitrate deposition. The change in nitrate deposition is less from its

model projections ranging from a value of about .3 percent at Charlottesville up to about a little less than 2 percent. The three coastal sites are showing values of improvement of about .4 percent. But again, these are probably conservative estimates of nitrates because of the CAIR -- the ruling on CAIR.

Q. Earlier in your exhibit binder, Dr. Driscoll, there's a map showing some of these NADP sites in relationship to some of the state parks and other scenic areas.

A. Yes.

Q. This is Plaintiff's Exhibit 324. Can you identify that and explain to us what it shows.

A. Yes. So this is a -- this -- I talked a little bit previously about the great resources in terms of federal parks and forests. There are equivalent state resources here so this is highlighting some very important state resources that are at risk in terms of atmospheric deposition. Mt. Mitchell, I talked about that previously. Lake James State Park.

So I've indicated a few of them here with the green symbols with the triangles to indicate they're forests. And I've got some coastal sites as well down along the coast where there are also state parks. And then you can see these yellow symbols, square symbols, these represent some of the NADP sites, sites in North Carolina, sites in Tennessee that I've been referring to where these wet deposition collectors have

been in place and are collecting deposition data.

Q. And based on the results that we just discussed about the impacts on deposition from TVA's coal-fired power plants and the improvements in deposition that would result from the additional emissions reductions sought by North Carolina from TVA, what kind of impacts and improvements would you expect at these scenic areas that are shown on Plaintiff's Exhibit 324 for identification?

A. Well, I think these impacts, as I said before, are very large. I was -- I was surprised that the values from the analysis were as large as they turned out to be.

So to try to put this in context. I'll give you two examples. So I think the EPA was trying to achieve 30 percent reductions in deposition of sulfate through the Clean Air Interstate Rule before it was vacated. So you're talking about nationally a 30 percent reduction. Here we're talking about levels of 8 to 15 percent, so for only a few facilities.

The other thing is that there's been a lot of analysis in the area about air pollution effects on ecosystems. There's been historically groups that have focused a lot on human health effects for good reason, but there is starting to be increased recognition that ecosystems are very important and so that has prompted analysis of developing secondary standards for air pollutants.

So I mentioned this air quality management report that I

was involved in for the National Resource Council and one of the recommendations that we made was that EPA really try to focus attention on developing quantitative standards for impacts of air pollution on ecosystems.

So one of the approaches that we've -- we have -- we recommended at the time was an approach that is known as the critical loads approach. The critical loads approach has been used for years in Europe and it's been used pretty effectively as a tool between managers and scientists to try to evaluate what are levels of air pollutants that ecosystems can tolerate.

And so to EPA's credit, EPA has started to do some pilot studies on critical loads approach. And there have been a number of critical load analysess that have been done for this region and they've shown that these areas are in what are called exceedance for critical loads. Critical loads are defined as the level of pollutant below which there are no adverse ecological effects. So in other words, if the quantity of a pollution is above that level, that's what we would refer to as an exceedance. So in other words, there's too much air pollution that an ecosystem or a watershed can possibly sustain.

So the analysis of critical loads for this region shows very, very large levels of exceedance, on the order of 50 percent for acidity. And so you can see that a level of

reduction on the order of 8 percent or 15 percent, that would go a long ways to helping to reduce those exceedances of critical loads.

Q. And could you also put these impacts and benefits in context with reference to natural background.

A. Well, the background levels, even with those levels we would still be well above background levels. Well above background levels, yes. So remember, background levels for sulfate, about 1.5 kilograms per hectare, for nitrate about .3. So we would be getting down closer for sulfate, but we'd be a long ways to go for nitrate.

Q. You mentioned you also considered the impact of acidification on soils and trees, Dr. Driscoll.

A. Yes, I did.

Q. Can you describe for us how acidification, acidic deposition impacts soils and trees. And is there a figure in your report that would help you explain it?

A. Yeah, I've got a conceptual diagram to try to illustrate some of those aspects.

Q. All right. So I'll refer your attention to Plaintiff's Exhibit 337 for identification.

A. Yeah, that's great. Yeah, this is --

Q. Can you use that in your explanation?

A. That's from my report.

So this is a conceptual diagram to try to illustrate the

dynamics of what we call nutrient cations which are very important in the structure and function of forest ecosystems. So these are things like calcium and magnesium. So we hear commercials about the value of calcium and magnesium, and ecosystems need calcium and magnesium just like we do. So this diagram tries to illustrate how calcium and magnesium come into the system and how they're lost from the system.

So there are two major pathways of calcium input. The big one is what we call weathering, and that's the breakdown of rocks and minerals. So rocks and minerals get calcium and magnesium as part of their structure. And as they break down and erode, that is released to the ecosystem and can be used by the ecosystem.

There's another input which is generally pretty small and that's in deposition. There's some that comes in in air, but generally most of it comes down -- comes in from the breakdown of rocks and minerals.

There are two loss mechanisms, two removal mechanisms of calcium. One that's very important for ecosystem function is through tree growth. Trees require calcium just like we require calcium and so as they grow and develop, they take up calcium from the soil.

The other mechanism by which it can be lost is through runoff. Calcium and magnesium dissolve in water and when the water flows through the watershed, they carry it off with it.

Sort of the price of doing business.

So in a sustainable system, the soil, which we call the soil exchange complex, soil has negative charges and it -- and calcium and magnesium have positive charges. So the soil particles have the calcium, magnesium adhere to them. So it holds it within the ecosystem.

How acid rain comes into this is that it causes these inputs of acids, the nitrates and sulfate, and that leaches the calcium and magnesium from the soil and results in depletion or removal. So it can remove large quantities of soil.

The rub is at sites that are very high elevations and very shallow soils, first of all, they're very base poor to start with. The soils around here are hundreds of thousands of years old. And some of these bedrock formations that we talked about, the silicaceous materials and granitic materials, are naturally low in cations so they're low to start with. But then acid rain removes -- removes them from the system and depletes them and that can cause two problems. It can cause health effects for vegetation. It also makes the system more sensitive to continuing inputs of acidic deposition. So there's less base around to neutralize what comes in in the future and that can have impacts in terms of surface water and surface water acidification.

Q. Can you give us some perspective on the rates that

nutrients are depleted from the soils in the southeast.

A. Well, we're fortunate that there was a review study that was done in the southeast a few years ago by a fellow named Tom Huntington who's with the U.S. Geological Survey and so there are -- there's some really great ecosystem research done in the south. So he took data from these long-term sites that we've been talking about where they have balances on calcium and they have good information about the calcium and soil. And so he summarized what were the quantities of calcium in these southern soils as well as what was the net loss of calcium that was being removed from these soils. So he saw very widespread net removal of calcium from these soils.

So to try to put this in context, I did -- I used some of Dr. Huntington's data and I did a calculation to try to give people a feel for the rates of depletion, and I believe there's a little figure in my report that illustrates this.

Q. Okay. I'll show you Plaintiff's Exhibit 341 for identification. Can you identify that, please, and show us what it -- explain what it shows.

A. Yeah, this is from my report. And this -- this is from these 12 sites and they're not all at high elevation sites. Some of these sites are in what we would consider to be relatively insensitive areas, areas in the Piedmont and so on and so forth. So these are all the data that are available.

And so what I did is I took the total quantity of

available calcium that's reported from those studies and I took the rate at which that's been depleted from the summaries that we were provided by Huntington and I calculated how much time it would take at current rates for that calcium to be removed to zero. Completely exhausted from the system. So what I found was that -- so this represents different bars representing the number of the different sites.

So I found that 5 of the 12 sites had calcium depletion rates which would suggest at their current rate, the calcium would be exhausted in less than 50 years. To me that's a staggering number given that these soils, they formed over hundreds of thousands of years. And it just shows two things. It shows that the background concentrations of calcium in these soils is very low and the rates of removal are very high. Then an additional two sites that would be depleted between 50 and a hundred years, and another two between a hundred and 200 years.

So I think the picture that Dr. Huntington painted here is that the rates of calcium depletion are very fast and quite widespread in the southeast.

MR. GOODSTEIN: Your Honor, at this time we offer 344, 321, 323, 322 and 325 into evidence, which are the figures and tables that we've just gone over with Dr. Driscoll.

MR. FINE: Counsel, did you also include 336?

MR. GOODSTEIN: I'm going to -- I'm going to reel off another set of numbers after we get this one taken care of.

MR. FINE: All right. On 323, which I believe was in your list.

MR. GOODSTEIN: Yes.

MR. FINE: We would interpose an objection insofar as it reflects information on sites far removed from the state of North Carolina.

MR. GOODSTEIN: That's the NADP data, Your Honor.

THE COURT: Note your objection.

(Plaintiff's Exhibits Numbers 321, 322, 323, 325 and 344 were received into evidence.)

MR. GOODSTEIN: And then I'd also offer at this time 326, 237, 334, 336, 324, 337 and 341 into evidence at this time.

MR. FINE: And we would interpose the same objection as previously to Plaintiff's Exhibit 336, Your Honor.

THE COURT: All right. Overruled.

MR. GOODSTEIN: Thank you, Your Honor.

(Plaintiff's Exhibits Numbers 237, 324, 326, 334, 336, 337 and 341 were received into evidence.)

BY MR. GOODSTEIN:

Q. Dr. Driscoll, can you explain to us how the acidification effects that you described cause the mobilization of aluminum

and what the implications of that are for the ecosystems that you looked at.

A. Yes. So when we think about water, we usually don't think about aluminum because aluminum is what we refer to as a relatively insoluble mineral, but it's actually a very abundant mineral. It's probably the most abundant metal in the soil. It's part of the matrix of soil, but it's very insoluble and only under extreme conditions can it be -- can it be removed or mobilized.

But when there are inputs of acidity and the pH, which is a measure of acidity, decreases, there is a potential to dissolve aluminum from soil and to release it from surface waters, and there have been a number of observations that -- extending back to my dissertation we mentioned that I worked on that for my dissertation, that have shown mobilization of aluminum under conditions of acidic deposition, including a number of sites in the southeast.

Q. I'll show you Plaintiff's Exhibit 339 for identification. And if you could identify that for us, please.

A. Yes. This is also a figure from my report and this is a -- this is a summary of a lot of data, hundreds of observations of surface water, aluminum and how it varies with pH.

So the vertical scale represents the concentration of aluminum and the scale along the side is the pH value. So it

ranges from about 4 up to 7.

And I've also got it color coded with different forms of aluminum. Aluminum can exhibit a number of forms, but for simplicity's sake, let's say there are two major forms of dissolved aluminum. It can be either in an organic form that's bound up with natural organic matter, decomposed leaf materials and things like that, or it can be in an inorganic form. And in most remote systems unimpacted by acid rain, the aluminum that's there, typically the concentrations are very low and it almost all occurs as organic aluminum or the nontoxic form.

So if you focus on -- I'll try to use the little -- if you focus on the neutral pH region up in 6 and 7, you can see that the concentrations of aluminum are low and most of the aluminum occurs in the green form or the organic form which is the nontoxic form. As the pH values decrease below 6, you can see that there is an exponential or an ever increasing increase in aluminum concentration, and that's entirely consistent with the theoretical solubility of aluminum mineral, so it's very well grounded in theory. It's what we would expect.

So just to try to put this in perspective, I put a little dashed red bar along the bottom and that refers to a level that we use for guidance for aluminum toxicity to brook trout. Brook trout is actually a fairly tolerant fish. It's a pretty

tough fish. But when aluminum concentrations get above 2 micromols, m-o-l, per liter, that's a concentration unit, then there will start to be toxic effects of aluminum. So you can see that once the pH of waters start to decrease below 6, the concentrations of aluminum increase above that limit. So aluminum is mobilized by acid rain from soil to water, to drainage water, soil water and ultimately surface waters.
Q. And what's the implications of that mobilization of aluminum on the ecosystem?
A. Well, aluminum is a toxic substance. It is toxic to plants. It's toxic to aquatic organisms, insects, fish. So it will have deleterious effects on ecosystems.
Q. And what levels of toxic inorganic aluminum did we see in soil waters?
A. Well, I have a figure from a site not too far from here, Noland Divide, which is in the park which is part of the Integrated Forest Study that we talked about previously with respect to deposition. They studied deposition, but they also studied the cycling of these elements in the ecosystem, including soils and trees, so on and so forth. So I have some of their data in this report.
Q. All right. So I'll show you Plaintiff's Exhibit 340 for identification.
A. Yes, that -- that's --
Q. Can you identify that, please, and tell us what it shows.

A. That's it. So these are studies that were done by researchers down in the park. It's part of this Integrated Forest Study that I mentioned previously.

And what you see are concentrations of -- concentrations shown along the vertical axis and how the concentrations change over time. And there are concentrations that are shown for three elements that we've been talking about: Magnesium is in red, calcium is in blue, and aluminum is in the black triangles.

So what you see here is over this period the concentrations were low during the early summer months; and in the fall when there was more water moving through the system, there was initial flushing of calcium and magnesium, so you can see some peaks in the calcium and magnesium as it's flushed from the system. So the acidity flushed these materials from the soil that we talked about before with respect to calcium and magnesium. Then once that was removed from the system, there is inadequate bases, calcium and magnesium, to neutralize the acidity. And you see that neutralization is now accomplished by the very, very high concentrations of aluminum.

So if I could draw your attention to the scale here, the previous figure, remember, I had that little dashed line at the bottom at 2. So the scale here is on the order of hundreds of micromols, m-o-l-s, per liter. So these are very,

very high concentrations of aluminum in the soil and water, among the highest I've ever seen in the literature. Extreme conditions.

Q. And would you expect the data you saw from this site to affect conditions in the area around it?

A. Yes. I think that the region around here is highly sensitive. There have been a number of studies throughout the region to show that there are very sensitive waters and there have been other soil solution studies that have shown elevated concentrations of aluminum in some of the other sites we've talked about, such as Mt. Mitchell and some of the other high elevation sites. So it's certainly not unique to the park.

Q. And what are the impacts of this mobilization of toxic inorganic aluminum? What are the impacts for the forests and for the surface waters in the southeast?

A. Yes. So as you say, that there are two potential problems associated with it. First of all, potential effects on trees and vegetation; and then also, if it -- if it makes its way to surface waters, there could be potential effects on surface waters because as I indicated, aluminum is toxic to aquatic organisms.

The concern in terms of forest vegetation has really been focused on red spruce. And as I've tried to indicate, you know, the inputs of acid rain have really altered the calcium and aluminum regime of these high elevation forests and that

has implications with respect to the health of red spruce.

An important component is what is referred to as the membrane-bound calcium. That's calcium associated with the membranes of foilage of red spruce. These very high inputs of atmospheric deposition, very high cloud inputs will leach calcium from the needles of red spruce.

Also, the low concentrations in soil restrict the ability of the plant to take it in because it's been leached from the system.

Also, high concentrations of aluminum will impede the uptake of water and nutrients to the plant.

So this will cause a stress to the plant and experiments that have been done by research around -- researchers around here have shown that if you experimentally add calcium back to the forest in the form of lime or something like that, that will reverse the effects and increase the aluminum -- excuse me, the calcium concentrations in foilage.

So why is this significant? Because this represents a stress to the plant and it makes the plant more susceptible to additional stresses. And one particular concern is the red spruce has a reduction in its tolerance to very cold conditions. It can result in freezing damage under very cold conditions. And this has been shown for studies of red spruce all up and down the Appalachian Mountain region.

The other thing -- the next thing that's been shown from

tree ring analysis is that the radial growth of red spruce has declined markedly since the 1960s, and this cannot be explained by climatic conditions or stand conditions.

Also, that decline in growth has coincided in tree ring analysis with changes in wood chemistry such that there is a decrease in calcium in the recent wood and increases in aluminum in the recent wood suggesting that there's a linkage between this altered calcium and aluminum status of these stands.

And finally, there have been sappling studies which have shown a reduction in photosynthesis relative to respiration which coincides with decreases in foliar calcium, increases in foliar aluminum and increases in soil solution aluminum.

And so I think those pieces of scientific evidence from a variety of studies really strongly suggests that the health of red spruce is impaired by high -- very high inputs of acidic deposition to the region.

Q. And did you summarize this evidence regarding acidic deposition and its effect on stress and poor health of red spruce in the southeast, and did you summarize that in a portion of your report?

A. Yes, that's covered in my report, yes.

Q. So referring your attention to Plaintiff's Exhibit 474 in evidence which is your report of October 27th, 2006. And referring your attention to pages 20 and 21. Is that a

summary of the evidence on acidic deposition and its contribution to stress and poor health of red spruce in the southeast U.S. that you just described to us? It's on Page 20 of Plaintiff's Exhibit 474.

A. I know it's in the report. I'm just not sure what page number.

Q. Okay.

A. Yeah, so it's right here on the screen.

So there are a series of bullets that I just talked about.

The first bullet pertains to the alteration of the calcium and aluminum status, and I cite a number of studies that document that.

And then the potential impacts on cold tolerance.

And then on Page 21 I talk about the reductions in regular growth and linkages to foliar -- or excuse me, wood chemistry and aluminum.

And then finally, the third point on the sappling studies about reductions in photosynthesis relative to respiration coinciding with low levels of foliar calcium, high levels of foliar aluminum and low calcium to aluminum ratios and soil solutions. That's addressed on that third bullet.

Q. All right. And can you summarize for us the geographic area that you concluded is impacted in the region.

A. Well, I showed -- if you remember back, I showed a map of

the SAMI region and those sort of greenish colors, those siliciclastic materials. So those areas, there have been -- these reflect a number of studies across the region in the spruce fur forests, so these are at high elevation sites. So the spruce will only really flourish at high elevations so these are really near the ridge top of the very highest elevations. So there are a number of studies throughout the region looking at red spruce effects, you know, not only in the park, but also at Mt. Mitchell and a number of other sites in the region.

Q. And in what states are the red spruce forests present in the southeast?

A. A lot of them are in Tennessee and North Carolina.

Q. All right.

A. The very highest elevations.

Q. And are there other ecological impacts of the soil calcium and aluminum levels in soil waters that you've described?

A. Well, the main effects are depletion of calcium/magnesium that we talked about, mobilization of aluminum. So those two conditions together coupled with the leaching, the direct leaching of foliar calcium from the foilage and the membrane-bound calcium will have these health impacts that we've just been talking about.

Q. What about physiological changes to organisms?

A. Yes. So you mean aquatic organisms?
Q. Yes.
A. Okay. All right. Yeah, so the -- so in addition to trees, there could be effects of acidification on surface waters.
And first of all, surface water acidification results in some chemical effects. So the increased leaching of sulfate and nitrate, if it's not neutralized by the bases, calcium/magnesium, will result in decreases in pH, increases in acidity and increases in aluminum concentrations in surface waters.
It also coincides with a decrease in this indicator that I mentioned way back in the beginning of my testimony, acid neutralizing capacity, which is abbreviated ANC. And acid neutralizing capacity is an important indicator. It's something that you can measure in the laboratory. And it's a measure of the ability of the system to neutralize inputs of strong acids. So we see those chemical effects and those chemical effects can translate into biological effects.
Q. So what is the effect of acid deposition on stream chemistry?
A. So as I indicated, it can have effects on pH. It can have effects on acid neutralizing capacity. It can have effects on mobilization of aluminum. And there have been surveys that have been done throughout the study region. In

fact, Bill Jackson, who I think you heard from earlier, was involved in a large survey of 256 streams on Forest Service lands throughout the region. I think I've got a summary table in my report summarizing some of his findings.

Q. I want to show you Plaintiff's Exhibit 348 for identification. And can you identify this, please, and explain to us what it shows.

A. Yes. So this is the summary table of values of acid neutralizing capacity of streams. Again, 256 streams that are on Forest Service lands in North Carolina, Tennessee and South Carolina. And these represent the percentage of values of acid neutralizing capacity.

And before I talk about this table, maybe I should give you some perspective on acid neutralizing capacity. I mentioned the ability of the system to neutralize inputs of strong acids. And it can have very high values. There can be acid neutralizing capacity values of 500 or a thousand or, you know, more than a thousand, multiple thousands. Microequivalents per liter. But these values that are summarized here are very, very low values.

And so what he found was of the streams that he sampled, 5 percent had values of acid neutralizing capacity that were negative. That means that they're chronically acidic. They all -- they have low pH values, high aluminum concentrations year round. 5 percent of the streams he surveyed.

Another 15 percent of the streams have acid neutralizing capacity between zero and 20 microequivalents per liter. These are very, very low values, but they're positive values. They're right on the cusp, if you will, of being chronically acidic.

And so these are generally values that are collected during low flow conditions, what we call base flow. And when the flow increases, like during storm events or during snow melt, the values of acid neutralizing capacity can decrease. They can decrease 10, 20, maybe 50 microequivalents per liter during events. So you can see that these values between 0 and 20 which are during base flow, then during high flow events they can easily dip down below 0. And so 15 percent between zero and 20. So these are very sensitive systems.

And then the next class is between 20 and 50. And there -- and these systems are also very sensitive and under high events can reduce the acid neutralizing capacity down to conditions that may be of health concerns to aquatic biota.

The reason why this was summarized at 50 is because 50 is generally thought to be a safe condition. Above 50 microequivalents per liter is generally thought to be a safe condition for brook trout. And brook trout is a very important, as I said, indicator for the area.

It's interesting because -- so about -- so generally we use 50 microequivalents per liter or less as being sensitive

to acidic deposition. So here we've got 49 percent of the streams surveyed are what we consider sensitive, and this was on Forest Service lands.

There have also been surveys that have been done in the park by park service personnel and university personnel that are working with them, and they find that 59 percent of the streams in the park have acid neutralizing capacity values below 50.

MR. GOODSTEIN: Your Honor, we offer 339, 340 and 348 into evidence at this time.

THE COURT: All right. Let those be admitted.

(Plaintiff's Exhibits Numbers 339, 340 and 348 were received into evidence.)

Q. Can you tell us, Dr. Driscoll, what kinds of impacts do the stream chemistry that we've looked at have on stream biology?

THE COURT: I think we'll take our break at this point and start back with that question.

MR. GOODSTEIN: Thank you, Your Honor.

THE COURT: Take a 15 minute recess.

(Brief recess at 4:15 p.m.)

THE COURT: All right, you may continue, Mr. Goodstein.

CHARLES DRISCOLL

DIRECT EXAMINATION (Cont'd.)

BY MR. GOODSTEIN:

Q. So Dr. Driscoll, we were finishing up our discussion of Plaintiff's Exhibit 348 and you were summarizing what your conclusions were about the impacts of these surface water stream survey results, what the implications of them were for aquatic organisms in the streams in this area. So can you describe that for us, please.

A. Yes. So we can look at effects of acidification on aquatic organisms at really sort of three different levels. And remember that acidity has impacts and the aluminum has impacts. So we can look at -- so there are effects at the individual organism level. Individual organisms growth is impaired under conditions of elevated acidity, so the conditions of growth will decrease with decreases in pH.

The second level of response are population level responses and these are shown from experiments where certain types of fish, let's say brook trout or dace, will either show sub-lethal or lethal effects to acidification. So these are typically experiments that are done within reaches and compared to unimpacted reaches and streams.

And the third level are really community levels where whole groups of organisms are impacted and that is manifested through decreases in biodiversity or species richness. So when the water quality is adequate, there are relatively limited impacts of acidic deposition. There will be a diverse

community, many different types of organisms. And with increases in acidification or increases in the levels of aluminum and decreases in pH, we will see the most sensitive species fall out first, be impacted, and what remains are species that are more tolerant. And so there can be a change in the types of organisms that occur under those conditions and decreases in the total number of organisms. So community level impacts.

Q. And did you look at some data about benthic, b-e-n-t-h-i-c, organisms?

A. Yes. So whole food webs are impacted. There's a lot of attention given to fish, but organisms that are fish food, the whole ecosystem is impacted.

So in the St. Mary's River, there are some unique datasets --

MR. FINE: Your Honor, I'd have to interpose an objection at this time. I believe the St. Mary's River is located in Virginia and we do object to any testimony concerning impacts on the St. Mary's River, an area far removed from North Carolina.

MR. GOODSTEIN: Your Honor, as Bill Jackson testified the other day, some of the best data available for this type of scientific information has been collected in the Shenandoah National Park and it's -- as Dr. Driscoll's testimony will explain, it's very applicable and important to

his conclusions that he's reached here.

THE COURT: Let's relate it to North Carolina if you do so.

MR. GOODSTEIN: Yes. He's just going to show some data from Shenandoah which he has used to reach his conclusions here because the same type of effects are going to be occurring here. I can lay a little more foundation for it if the court would like me to.

THE COURT: I'm interested in the impact in North Carolina as this objection --

MR. GOODSTEIN: Yes, that's what we're talking about, Your Honor.

THE COURT: All right.

MR. GOODSTEIN: But part of his -- part of Dr. Driscoll's analysis was to look at the available studies on impacts on acidification and the impacts on benthic organisms in streams and some of that data has been published from the Shenandoah. It doesn't mean we're not focused on impacts here in this area. It's just related to his analysis.

THE COURT: All right.

MR. GOODSTEIN: Thank you, Your Honor.

BY MR. GOODSTEIN:

Q. I'm going to show you Plaintiff's 349 for identification, Dr. Driscoll. Can you identify this and explain to us what it shows.

A. Yes. This is a figure from my report. As I mentioned previously, there's a unique dataset for the St. Mary's River and where researchers have collected the total quantity and the distribution of benthic invertebrates, insects, if you will, over time and looked at species impacts.

So in the large box you see the total number of organisms. And part of the reason this study is so valuable is because it dates back to the '30s, being decades ago, and then measurements were continued in the '70s and '80s and through the '90s.

And so what we see is that looking at those data in the '30s, the total quantity of benthic invertebrates within this site in the St. Mary's River were high and they have dropped down substantially over time.

If you look on the far right, the distribution of individual species is shown so there is a box for mayflies and a box for caddisflies and a box for leuctra, which is a stonefly, and then lastly, midges. And while there's been some decrease in the overall numbers, there have been large shifts in the distribution between these species or among these species. So mayflies and caddisflies are among the most sensitive species so you can see that their numbers decrease down to fairly low levels in recent years and those numbers have been replaced by these other species which are more tolerant and therefore become more abundant, like the stonefly

and the midge. So not only are there changes in total numbers, but there's also changes in the distributions.

Q. And has this change in benthic organisms, would you expect this type of change to be occurring in the region -- the higher elevation streams that were surveyed by the U.S. Forest Service, the data that you just presented?

A. Yes, the benthic invertebrates are found throughout the region. Their responses appear to be strongly driven by water chemistry. The chemistry is the chemistry. And so organisms -- in fact, studies all up and down the northern Southern Appalachian Mountains have shown remarkably similar results across different species. So I think studies from one area can be extrapolated to another area.

One of the challenges here with respect to biology studies, although people relate to biology, their -- the studies are much less frequent than chemical studies. They're very difficult to do. They're very time consuming. They're very expensive. So the number of biological effect studies is much less than chemical effect studies.

Q. So your conclusion is that acidification effects on benthic organisms similar to the ones that you summarized in Plaintiff's Exhibit 349 are occurring in the mountain streams in Tennessee and North Carolina as a result of acidification.

MR. FINE: Your Honor, object to leading his witness.

THE COURT: Overruled.

MR. GOODSTEIN: I'll rephrase, Your Honor.

THE COURT: I'll let him answer.

MR. GOODSTEIN: Okay.

A. Well, in my report I have another study which is a survey across the region which shows these chemical effects occur for these same three species across the region. So this is a time study which shows the changes with time. But there also have been surveys done which cross a spatial region so you can use the spatial variation as a surrogate for the variations in time. So some areas are more sensitive; some areas are less sensitive. So you can look across the region. And the temporal pattern that I showed here with the sensitivity of these organisms, particularly the sensitivity of mayflies and caddisflies relative to stoneflies is evidence across these surveys in the region.

Stoneflies, too, are impacted, but the degree to which they're impacted is less severe than the mayflies and caddisflies. So I think these data for the St. Mary's River are highly relevant across the region.

Q. And is it your conclusion that these same impacts on benthic organisms from acidification are occurring in the streams in the Great Smoky Mountains National Park based on your review?

A. Yes.

Q. And can you tell us about the impacts on fish from acidification that you analyzed and issued a report on.

A. Right. So we talked about community level impacts for different types of species. So these examples in this last figure for benthic invertebrates are an example of that, but it's also very relevant to fish. People are very concerned about fish. It's a very important resource for the region.

So I had a figure which summarized results of fish surveys, spatial surveys of fish distribution. And I believe I have a visual on that.

Q. Let me refer you to Plaintiff's Exhibit 355 for identification. Can you identify that and explain what it shows, please.

A. Right. This is, as I said, based on surveys of the number of fish species in different streams across the region. And so the vertical axis, the number of different types of fish that are found within a reach and along the scale at the bottom there are values of acid neutralizing capacity. And you recall that we talked about acid neutralizing capacity as being an important indicator of the acid base status. So if the acid neutralizing capacity of a stream is a hundred or maybe greater than a hundred, the number of different types of fish species that might be expected would be on the order of six, seven, eight. So it would have a fairly diverse community. As the acid neutralizing capacity decreases, then

the number of fish species decreases.

So I mentioned some time ago about brook trout. Brook trout is a very important indicator for the region. And brook trout, it's sort of like -- it has advantages and disadvantages. Brook trout, people are very interested in brook trout. It's very important and so in that respect it's a very important indicator.

But the downside of brook trout is it's a very tolerant fish. It's a very tough fish and it takes extreme conditions under which it's impacted. So when the acid neutralizing capacity is above 50 microequivalents per liter, where a sensitive fish species might have fallen out long ago, brook trout can still survive and flourish. The habitat is adequate. But when the acid neutralizing capacity decreases below 50, even brook trout might be impaired. And there will be different species of fish that have different sensitivities. As the acid neutralizing capacities get lower and lower and lower, the species' richness, the number of different types of fish species decreases and under extreme conditions you have a fishless surface water. So the chemical conditions are not able to support fishery.

Q. Dr. Driscoll, can you please summarize for us your conclusions regarding the impacts of TVA's excess emissions on surface water chemistry and biology.

A. Yes. So the impacts of acidic deposition on surface

waters include decreases in pH, the mobilization of aluminum. So low pH and high aluminum conditions can have adverse effects on aquatic organisms. Can have impacts on all levels of the food chain. Can affect individual organisms. Can affect particular species. And can also impact whole communities of organisms, whole groups of fish.

Q. You have a table in your report that summarizes the brook trout response to acidification.

A. Yes, I do.

Q. I'll show you Plaintiff's Exhibit 351 for identification. Can you identify that and explain what it shows.

A. Yes. So one of the things I wanted to do was to try to link the chemical conditions and what would be the biological response to those chemical conditions. So because brook trout is such an important resource, I selected brook trout. Again, realizing that it's a fairly tolerant fish.

So when the habitat is suitable and the values of acid neutralizing capacity are above 50 microequivalents per liter, then brook trout will do fine. When the acid neutralizing capacity starts to decrease below 50, there will start to be effects. So the effects will be more subtle at first and become more severe with decreases in acid neutralizing capacity.

When the acid neutralizing capacity range is between 0 and 20, there can be what we refer to as episodic events.

These are storm events or snow melts where there will be short-term changes on the order of hours to days that will cause adverse chemical conditions and there could be either lethal or sub-lethal effects on brook trout in this range.

And then when the acid neutralizing capacity values are below zero, that's, as I said before, chronically acidic conditions and lethal effects on brook trout, a very tough fish, is probable.

So if you remember back when I talked about the chemical conditions from the surveys of the Forest Service lands and the Park Service lands, 50 percent of the Forest Service streams have acid -- 49 percent have acid neutralizing capacities below 50 microequivalents per liter and for the park surveys 59 percent have acid neutralizing capacities less than 50. So in the sensitive range.

Q. And what can you tell us about the current trends and the future trends on soil and streams acidification in the southeast region?

A. There are two areas where there are long-term measurements of surface water chemistry: One is in the park, which is Park Service and University of Tennessee observations, and then one is in Virginia. They show similar patterns, although the record from Virginia is longer, but what they are showing is that over the -- I'll focus on the park data.

The park data showed that the values of pH are actually decreasing from the early part of the studies which was the early 1990s till today. In the lower elevation sites the pH values are decreasing. And this is despite very small decreases in sulfate which are probably in response to decreases in emission reductions that we talked earlier in the testimony. And the reason -- this is sort of counterintuitive that sulfate is going down but the streams are getting more acidic. But the effects are twofold.

One is that the area receives very, very high leaching losses of nitrate. The nitrate losses are actually higher than the sulfate in the park.

And second, the process of soil cation depletion. And if you remember, I talked about when the acids leach the calcium away, it makes it more sensitive to future acidification. So that's one line of evidence.

The other line of evidence is from the SAMI model calculations. As part of the SAMI study, there were simulations that were done by the MAGIC model, which stands for Model of Acidification of Groundwater in Catchments. It was one of the tools that was used under SAMI and they made projections under the base case scenario, and that's the Clean Air Act scenario of what the future would hold. And what the future is projected to hold based on these model calculations is that there would be ongoing depletion of calcium within

these watersheds that would make the system more sensitive to inputs of acidic deposition and there will be ongoing acidification.

So that's consistent with these long-term measurements over the last decade or two from both Virginia and from the park.

Q. So in conclusion, what is the significance of the impacts of TVA's excess emissions on acid deposition in the region?

A. Well, we talked about previously the concept of critical loads and the analysis by Forest Service personnel have indicated that these parks and wilderness areas are in exceedance with respect to critical loads of acidity.

So the fact that if we continue reductions -- if we continue with the levels of reductions that we have, they are not adequate to arrest soil acidification. That the soils are continuing to lose base cations and are continuing to acidify.

So the reductions that the State of North Carolina is suggesting for TVA facilities would go a long way in achieving those reductions. We're talking about reductions of levels of acidity at sites -- in the Smokys on the order of 12 to 14 percent. So those are substantial reductions in acidity and would go a long way at reducing the soil acidification and associated surface water acidification and the associated biological consequences of those processes.

Q. And based on the recent studies that you reviewed, what

percentage of acid deposition reduction is necessary to reach the critical loads for sulfur deposition in Great Smoky Mountains National Park?

A. Well, the Forest Service report that I've seen suggests that for the highest elevation sites, they considered reductions of both sulfate and nitrate together because both of them drive the acidification process. And they suggested reductions on the order of 50 percent at the highest elevation sites.

Q. And based on your analysis, what percentage reductions at those high elevation sites are you projecting to result from the reduced emissions from TVA power plants sought by North Carolina?

A. So the percent reductions at the site, I think at the Smoky sites, if you summed up sulfate plus nitrate, it was on the order of, as I said, 12 to 14 percent reduction.

Q. And would you expect similar types of reductions in deposition and reductions in the adverse impacts that you've described today associated with deposition at the state parks and the wilderness areas in the mountain regions of Tennessee and North Carolina that you identified for us earlier?

A. Yes, I would.

Q. And will these reductions in acidification and the adverse impacts associated with that, in your opinion, is that going to improve the structure and function of these

ecosystems?

A. Yes. So as I've tried to indicate, the structure and function has been impaired really fundamentally. There have been changes in soil processes, the development of soils, effects on surface water quality that has cascaded into effects on trees, effects on aquatic organisms. And so these areas are clearly impacted and anything that can be done to reduce the deposition would result in improvement in not only the chemistry but also the structure and function of these systems.

Q. All right. Dr. Driscoll, can we talk about mercury now?

A. I'd love to talk about mercury.

Q. Okay. Can you just give us an overview of the processes that result in mercury deposition.

MR. GOODSTEIN: And if it will assist you in approaching the pad, I ask for the court's permission, Your Honor, to allow Dr. Driscoll to approach the pad?

THE COURT: All right.

MR. GOODSTEIN: I think that will assist him in his testimony. Thank you.

(Witness stepped down from the witness stand.)

THE WITNESS: Your Honor, you're going to have to bear with me. Drawing is not my strong suit, so I'll do the best I can.

Okay. Mercury is an air pollutant. It's

actually -- the air pollution is the dominant pathway by which mercury is deposited to the land's surface globally.

Mercury is really interesting. It's really very complicated, very, very interesting. Mercury is a natural substance. It occurs naturally. It's released from volcanos. There are mineral deposits that are naturally enriched in mercury that can be released to the atmosphere. But it's also -- its release to the atmosphere is also increased by human activity. And so best guesstimates worldwide are that mercury's emissions, the release is three times what was natural. So there's been a three times enrichment in the quantity of mercury in the atmosphere as a result of human activities. In certain areas -- so, for example, I do a lot of work in mercury in my area. We see enrichments of a factor of 5, 7, up to 20 above background values. And I'll -- you know, and I'll tell you how we estimate that.

One of the things that makes mercury interesting is that there are different forms of mercury that are released. There's elemental mercury. And elemental mercury -- so when I was a kid, our teachers used to give us beads of mercury that we would use to amalgamate dimes. That is elemental mercury. Elemental mercury has a long, relatively long residence time in the atmosphere. It can reside in the atmosphere about a half a year. Now, that's on average. There are processes that will remove elemental mercury close to the source.

The other form of mercury that's released is called oxidized mercury, or it's also referred to as ionic mercury. And these forms of mercury are very reactive. Oxidized mercury can be in a particulate form or it can be in a gaseous form and it falls out very close to the source, within hours to days.

So elemental mercury is a global pollutant. It can be a local pollutant or a regional pollutant, but it's clearly a global pollutant. Oxidized mercury is a local and regional pollutant. They're all mercury, but there are different forms that are released.

That mercury, just like acid rain, will be deposited by the same processes that we talked about: Wet deposition, dry deposition, cloud deposition. But for dry deposition of acid rain, the quantity -- you know, I think the data that we showed for the Smokys was maybe on the order of, oh 30 percent, 40 percent of the total. For mercury, dry deposition is a much higher percentage. Maybe up to two-thirds or three-quarters of the total. So wet deposition of mercury is generally a smaller portion of the total. It's mostly dry deposition. So mercury is deposited.

Now, that will not really affect people or humans. It needs to undergo transformations in the environment. So this ionic mercury, some of it is retained in soils. Some of it can be released back to the atmosphere. But some of it

moves with water into surface waters. When that mercury in water is in contact with wetlands or lake sediments, it can undergo a process of transformation which is known as methylation, and it forms -- it forms a compound that's known as methylmercury.

The interesting thing about this process is that it's done by specialized bacteria. Those same bacteria process sulfate. So as they're processing sulfate, as a byproduct of that process, they produce methylmercury.

Okay. So why is this -- why is this important? Why is this significant? Because methylmercury strongly bioaccumulates through food chains. So methylmercury will be taken up by algae, and then by the insects that eat algae, and then by the small fish that eat those insects, and then the large fish that eat the small fish. And this process is known as bioaccumulation.

The interesting thing about this is concentrations of methylmercury in water are very low. We have to go through elaborate procedures to sample and analyze it. We have to collect it with gloves and suits to make sure we don't contaminate. The concentrations are on the order of what we call parts per trillion. Very, very low concentrations. But this process of bioaccumulation increases the quantity of mercury by 1 to 10 million. So we will have relatively low concentrations in water, but the process, as it's taken up

along the food chain, it concentrates all along the way so that the quantities in fish can be high enough, it can cause health problems for humans or wildlife.

Now, I've spoken about this for the aquatic food chain, but there is recent research which also suggests that similar process is occurring for the terrestrial food chain. So methylmercury is converted. It's taken up by insects. Those insects are eaten by spiders. Spiders are a key process. There's a great enrichment in methylmercury in spiders. And then song birds, which consume spiders, show very high concentrations of methylmercury. It's a very widespread problem. It's the -- there are more consumption advisories for mercury than all other contaminants. All states in the eastern half of the U.S. have some sort of consumption advisories for mercury. So it's a very -- it's a very widespread problem.

Q. Thank you, Dr. Driscoll.

(Witness resumed the witness stand.)

Q. Based on your review, do North Carolina, Tennessee, Alabama and Kentucky have consumption advisories for mercury?

A. Yes, they do.

Q. I'll show you what's been marked for identification as Plaintiff's Exhibit 48. Can you identify that?

A. Yes. So this is material from the Department of Health from the State of North Carolina which indicates consumption

advisories for specific bodies of water in North Carolina, and these are consumption advisories for largemouth bass and chain pickerel. There are also coastal advisories as well for the state of North Carolina.

Q. And is some of this mercury contamination that's going on in the southeast region, is that coming from emissions from coal-fired power plants like the ones that TVA operates in Kentucky, Tennessee and Alabama?

A. Yes, that's the case. In fact, coal-fired utilities are the largest unregulated source of mercury emissions in the country.

MR. GOODSTEIN: Your Honor, if I could, I'd like to mark the pad exhibit Plaintiff's Exhibit 489 and offer that into evidence, please.

THE COURT: All right. Let it be admitted.

(Plaintiff's Exhibit Number 489 was received into evidence.)

MR. GOODSTEIN: And we also offer Plaintiff's Exhibits 349, 355, 351 and 48 into evidence at this time, Your Honor.

MR. FINE: Your Honor, I object to Plaintiff's Exhibit 349 on the grounds previously mentioned. It is dealing with areas outside of North Carolina.

We'd also object to Plaintiff's Exhibit 48. The document appears to be hearsay. I'm not sure Dr. Driscoll is

in a position to lay an adequate foundation for its admission.

THE COURT: All right. Objections are overruled.

(Plaintiff's Exhibits Numbers 48, 349, 351 and 355 were received into evidence.)

Q. Dr. Driscoll, did you consider the estimated impacts on mercury pollution in the region that are emanating from TVA's coal-fired power plants at issue in this case and the reduction that would result from the additional controls sought by North Carolina on those emissions?

A. I did. I considered the estimates that were provided by Dr. James Staudt who considered controls sought by the State of North Carolina and what they might translate to in terms of emissions reductions for actually sulfur dioxide, nitrogen oxide as well as mercury. And I think what we found was that these controls would result in about a 50 percent reduction in mercury emissions from these TVA facilities.

Q. I'm going to show you Plaintiff's Exhibit 53 which is in evidence. It should be the next in order in the book, Dr. Driscoll. And can you explain to us how you considered these estimates by Dr. Staudt in your analysis.

A. Yes. So as I said, these are levels of reductions of sulfur dioxide, nitrogen oxide and mercury for the year 2013 from Dr. Staudt showing the base case emissions and then what we thought would be the emissions that would occur if the controls that were sought by the State of North Carolina, if

they would be implemented. That's the second row. And then the third row is the difference between those two. That's the reduction. And then the final last row is the percent reduction of those emissions.

So the column on the right refers to mercury. And so you can see that there is a 54 percent reduction in mercury that's estimated from these controls.

Q. What are the implications of these reductions and emissions for the ecosystems that are receiving this mercury contamination from TVA power plants?

A. Well, as I mentioned previously, most of the watersheds in this country, the source of mercury is from atmospheric deposition. So this is very important in terms of the inputs of mercury that these systems are receiving. So this would result in a reduction and lowering of mercury to ecosystems in the region. As I indicated, there are consumption advisories for all the states in the region, including Tennessee, North Carolina, Alabama, Kentucky and the other states that I considered in my region.

The other, I think, important consideration which I mentioned in my primmer is the linkage between sulfate and mercury. There have been a number of studies which have experimentally shown that additions of sulfate will stimulate the production of methylmercury, and there have been papers that have shown that reductions in atmospheric sulfur

deposition will result in reductions of fish mercury. So it's likely that there can be a double benefit associated with this, not only the direct effect associated with the mercury emissions, but the added benefit that the reductions in sulfur may decrease the formation of methylmercury and that's the form of mercury that accumulates in fish. So it could be a double benefit associated with both the sulfur and mercury emission controls.

Q. Did you also consider some estimates from Dr. Staudt about the percent of oxidized mercury that was being emitted from TVA plants?

A. Yes, I did.

Q. I want to show you Plaintiff's Exhibit 103 which is in evidence. And can you explain to us what that shows and how you considered it in reaching your conclusions.

A. Yes. So these are the TVA facilities. This is -- this is a table from my report as we've indicated. So this is a -- it shows the individual TVA facilities.

And the third column is Dr. Staudt's estimate as the distribution of mercury -- if you recall in my primmer, I said that there are two major forms of mercury. There is elemental mercury which has a long time residence time on average in the atmosphere but can fall out fairly close to the source, and then oxidized mercury which generally will fall out from hours to days after emissions.

So you can see that several of these facilities, notably Bull Run and Kingston, have very high estimates of oxidized mercury. Many of the other facilities have very high fractions of oxidized mercury.

So under these circumstances controls would -- and reductions in emission would result in impacts in terms of improved reductions in mercury deposition fairly close to the source.

It's probably useful to point out that two of these facilities, the facility at Bull Run and the other facility at Kingston are fairly close to the park. They also were implemented with SCR technology and SCR technology tends to promote the formation of oxidized mercury. So in other words, putting the mercury in a form that it becomes more readily transported to the immediate surrounding area.

Q. So if scrubbers were installed on those plants at the same time the SCRs were installed, what effect would that have had on the percent of oxidized mercury being emitted from those plants?

A. Well, it would reduce the total quantity of mercury and it would certainly reduce the quantity of oxidized mercury.

Q. And based on your experience, is the mercury from TVA's excess emissions being deposited in Kentucky, Tennessee, Alabama and North Carolina?

A. Could you repeat the question.

Q. I'm sorry. Based on your experience, is mercury from TVA's excess emissions being deposited in Kentucky, Tennessee, Alabama and North Carolina?

A. Yes, and other states in the region, yes.

Q. And will the reductions in emissions sought by North Carolina in this case reduce the deposition of mercury in those states?

A. Yes.

Q. So in conclusion on mercury, Dr. Driscoll, what effect will these emissions reductions sought by North Carolina have on the overall mercury pollution picture in these states?

A. Well, it should improve the mercury status of these regions twofold.

First of all, there will be improvements in terms of direct reductions in the emissions which should have impacts on the deposition locally and regionally and globally, I might add.

And second, the reductions in sulfate should also result in decreases in the extent to which methylmercury is formed and there could be benefits associated with lower methylmercury production associated with the reductions in sulfate.

Q. And what is your overall conclusion about the improvements to acid deposition and the adverse effects on ecosystems that you've outlined for us today? What's your

conclusion about the reductions sought by North Carolina in this case from TVA emissions and what effect that will have on acid deposition in the region?

A. So the proposed controls by the State of North Carolina, if implemented, would result in sizable reductions in deposition of both sulfate and nitrate, particularly in the sensitive areas near here that we talked about. And that would undoubtedly improve the chemical condition that would result in decreases in deposition which will improve the chemical condition that we've talked about, diminish soil acidification, diminish surface water acidification, and that would improve -- help improve the structure and function of these impaired systems.

Q. And you've had an opportunity to review the expert report of Dr. Grigal who is going to be testifying for TVA in this case.

A. Yes, I have.

Q. And you attended Dr. Grigal's deposition.

A. Yes, I did.

Q. Did his deposition testimony or did his reports cause you to reconsider any of your conclusions?

A. No.

Q. And why not?

A. Well, first of all, I felt that Dr. Grigal pretty much agreed with the science that was presented in my expert

report. And I guess this is not surprising. There's been a lot of work done to characterize the science over the last three decades and I think this -- you know, if I might say, there's scientific consensus in terms of the process of acidification soil and surface water acidification and the ecological effects of that acidification.

There were a couple points, technical points that Dr. Grigal brought up mostly pertaining to mercury where he didn't agree, but I think by and large there was -- he agreed with the vast majority of the findings of my report.

Q. What about his comment that you may not see the controls on mercury -- or the reductions in mercury emissions that would result from the additional controls sought by North Carolina on TVA plants, you wouldn't see the benefits of that in this region?

A. Well, in Dr. Grigal's report he discussed the importance of elemental mercury and stressed elemental mercury as a global contaminate. And indeed, elemental mercury does have a relatively long residence time in the atmosphere. But there are mechanisms by which elemental mercury can be deposited locally and regionally. So for example, ozone. Ozone breaks down elemental mercury, converts it to oxidized mercury and allows for local and regional deposition. And the ozone concentrations are fairly high in the region.

Second of all, the stomata of trees, and these are the

pores, the openings in the leaves of trees, will take in elemental mercury and cause it to be fixed. And, of course, this area has an abundance of forest resources and so that's an extremely important pathway by which elemental mercury can be deposited locally. In fact, for forested systems, it's the dominant pathway. So there are mechanisms of elemental mercury depositing locally and regionally.

But more importantly, I think he ignored the importance of these oxidized or the very reactive forms of mercury. And as we just talked about in the table that I summarized from the analysis of Dr. Staudt, a lot of these facilities have a very high fraction of their mercury emissions as oxidized mercury. And we would expect those facilities to be -- those emissions to be deposited locally and regionally.

Q. What about Dr. Grigal's comment that it could be hard to document improvements to soils that you've outlined today in your report?

A. So it's interesting he made this comment because I think, you know, maybe 15 years ago, maybe 10, 10 to 15 years ago, the scientific community felt that soils were such a vast resource that they couldn't be impacted by something like air pollution. But we know today that that's simply not the case.

So I think in my -- earlier I talked about Dr. Huntington's study where he looked at 12 different sites throughout the southeast and he documented loss of calcium at

these sites. And there have been, you know, 20 to 50 studies over the last ten years that have used a variety of approaches to document impacts on soils. Where there have been either repeated sampling. Where it's shown that there have been shown to be decreases in calcium over time from sites where investigators have gone back and resampled. Or through tracer studies, looking at isotopic tracers to infer deposition rates. Modeling studies. There have been a whole host of approaches that have been used.

So there's, I think, clearly scientific consensus in the literature that this phenomenon is going on and so I -- I don't really think there's any basis for Dr. Grigal's contention there.

Q. And what about Dr. Grigal's comment that he's not sure whether decreases in sulfur dioxide emissions will result in this co-benefit of reducing methylation of mercury?

A. So again, as I mentioned a few minutes ago, there have been a number of experiments, experiments done in Europe, experiments done in Canada, experiments done in the U.S. where investigators have artificially added sulfate experimentally to wetlands or lakes and shown that that will stimulate the production of methylmercury.

There have also been detailed studies which have looked at the role of changes in atmospheric deposition of sulfate. We know that sulfate emissions peaked in the early 1970s and

have been decreasing over time where there are time series measurements of fish and mercury and pointing to the fact when there's a decline in fish mercury and the absence of declines in mercury strongly correspond to the decreases in atmospheric sulfur deposition. So I think there's a lot of scientific evidence to suggest this interaction. And we know clearly that sulfate producing bacteria are the main processes that drive formation of methylmercury. And to the extent that they're limited by sulfate, then there's going to be a cause and effect there. So again, I don't agree with Dr. Grigal's conclusion.

Q. And what about Dr. Grigal's comment that there won't be significant improvements in the ecosystems in the region resulting from the additional emissions reductions sought by North Carolina? Do you agree with that?

A. Well, that's really the bottom line, isn't it? What is -- what is significant? And in my analysis, I try to be extremely conservative. I try to focus on only those systems that have demonstrated impacts from the scientific literature. And as we talked about, these critical load analyses show that these areas are in exceedance with respect to inputs of acidic deposition. So these areas are already showing impacts. And so I would argue that any reduction, even one molecule will be an improvement.

But the levels of reductions that we're talking about

from the CMAQ calculations show levels of reductions for sulfur on the order of 4 up to over 20 percent down here in the southern part of the system, and for nitrate on the order of .4 up to almost 2 percent. And as we talked about earlier in the afternoon, that those are -- those are probably conservative because of the assumption that CAIR would be in place when those -- when those calculations were done.

So I strongly disagree. In fact, I think I mentioned at the beginning of the testimony that I was surprised at the magnitude of the reductions. They're very large in my mind.

Q. And would those benefits to ecosystems accrue in Alabama, Kentucky, Tennessee and North Carolina?

A. Yes. As we talked about from the SAMI analysis, there are sensitive areas in there. Those areas all have mercury advisories. We see elevated inputs of mercury. So to the extent that those emissions would result in deposition in those areas, then there would clearly be benefits to those areas as well.

MR. GOODSTEIN: If I could have a moment, Your Honor.

THE COURT: Yes.

(Co-counsel conferred.)

MR. GOODSTEIN: I have no further questions of Dr. Driscoll at this time, Your Honor.

MR. FINE: Thank you, Your Honor.

CROSS EXAMINATION

BY MR. FINE:

Q. Good afternoon, Dr. Driscoll.

A. Good afternoon.

Q. I have a number of points to cover. I may be doing a little jumping around. If I get myself or you confused, please let me know.

A. Okay. Will do.

Q. Thank you, sir.

A couple general things. First, I believe you testified that you relied on the information you received from the CMAQ modeling from STI?

A. That's correct. Sonoma Technologies, that's correct.

Q. And that you also relied on information from Dr. Staudt.

A. That's correct.

Q. So -- and am I correct in stating that you did not independently verify that information you received from Sonoma Technologies and Dr. Staudt?

A. I didn't independently verify it, but I -- in terms of -- certainly not with respect to Dr. Staudt's analysis of the effects of the emissions. But with respect to Sonoma Technologies, I did examine regional deposition and compared them to the CMAQ results. Admittedly, it's for 2013 compared to current values, but the patterns seem very reasonable.

So I wouldn't consider it a very rigorous evaluation, but

I did look at the results and compared them to current patterns of deposition.

Q. Thank you, sir. But you will agree with me, will you not, that if either Dr. Staudt or Sonoma Technologies provided you incorrect information, that that would have some impact on the conclusions that you've reached?

A. Conclusions with respect to CMAQ and conclusions with respect to the analysis of emission controls that Dr. Staudt did, yes.

Q. Let's talk about mercury first of all, if you wouldn't mind. And I'd like to use the -- I think the notebook that you already have available to you from your attorney.

First of all, let's look at the document that's already been introduced into evidence, Plaintiff's Exhibit 103.

A. Yes.

Q. I believe that's a chart prepared by Dr. Staudt.

A. Yes.

Q. And I think you already alluded to this, but just so that it's clear in the record, there is a significant co-benefit in terms of mercury reduction from the combination of a scrubber and an SCR.

A. Yes.

Q. And in fact, on Dr. Staudt's own chart he notes that scrubbed plants have low percent of oxidized mercury.

A. That's correct.

Q. Sir, would it surprise you to know that TVA is about to start up a scrubber at the Bull Run plant?
A. That's great.
Q. And that would have --
A. That's good news.
Q. -- significant co-benefit in reducing the percent of oxidized mercury as indicated on this chart.
A. That's great. I think that's good news. That's great to have the reductions in mercury. I think that's very good.
Q. And would it surprise you that TVA has a scrubber -- actually, two scrubbers that are over 60 percent complete at the Kingston plant?
A. Again, that's great. I think -- mercury is a toxic substance. It's a very widespread contaminant. And I think if it can be reduced, I think that there will be great benefits. So I think that's great news.
Q. And that the TVA board has announced that it will be installing -- that TVA will be installing scrubbers and SCRs at the John Sevier plant.
A. Very good. Bravo. I think that's wonderful.
Q. And you would agree with me, Dr. Driscoll, that there are -- many questions about the environmental benefits of emissions reductions from mercury remain unanswered?
A. Can you clarify what you mean by that.
Q. Well, sir, perhaps you can clarify what you meant by

that.

A. Okay.

Q. I'm quoting from an article in which you appear as a coauthor in the January 1st, 2005, edition of Environmental Science and Technology.

A. Okay.

Q. Which I believe is an American Chemical Society publication.

A. Yes.

Q. And you were listed as a coauthor on that article.

A. Yes.

Q. Now, I understand, Dr. Driscoll, you published many articles, but I would hope that you might have some recall of this one.

A. Oh, yeah, I remember. I just want -- I was just asking you to try and focus the question. Your question was fairly broad so I was just trying to have you focus it a little bit for the specific issues that you were interested in addressing.

Q. Well, Dr. Driscoll, I'm really asking you your agreement as to words that you are listed as the coauthor in an article on.

A. Well, I can talk about -- I'll talk about one thing that I'm working on and if it's not adequate, we can go on --

Q. No, excuse me, Dr. Driscoll. I appreciate your

helfulness, but I was asking would you not agree with me that there are many questions about the environmental benefits of emissions reductions for mercury that remain unanswered?
A. Of course.
Q. All right. And you'd also agree with me that "the problem is that the terrestrial-aquatic mercury cycle is complex, with many non-linear processes that link atmospheric mercury emissions and methylmercury bioaccumulations in fish and wildlife."
A. Yes, we talked about that.
Q. "As a result, how effective emissions reductions will be in decreasing biotic methylmercury levels in freshwater, estuarine and coastal ecosystems is not clear."
A. Well, we -- I think we know fairly well that reductions in mercury emissions will result in reductions in deposition. There have been a number of paleoecological studies that have demonstrated that cause and effect relationship fairly effectively.
I will agree that those additional linkages between the transport of mercury and watersheds, the methylation and then subsequent bioaccumulation of mercury are impacted by a variety of processes, one of which is mercury deposition. But there are other processes such as the supply of sulfate which we talked about as well. So clearly it's a complicated process and there are a lot of factors that can impact it as

that mercury is transferred from the atmosphere to fish.

Q. Thank you, sir. We'll return to the issue of sulfur and the methylation in a few minutes.

Let me also ask you if you agree with this statement? "Although the time scale is not well determined, the route of mercury through watersheds to the aquatic system is thought to be slow and convoluted. It has been estimated that only a relatively small amount of the total input of mercury to most watersheds, typically less than 20 percent, is transported to the associated aquatic system."

A. Yes, that's -- those are typical values. 20 percent, yes.

Q. And you also agree with me that "detection of the response to changing anthropogenic mercury emissions in the Continental United States will be confounded by variations in natural emissions, the rate of re-emission of previously deposited mercury and mercury emissions from other countries?"

A. Yes.

Q. And again, sir, you'd agree that "mercury export from watersheds is typically a small fraction of the yearly input from the atmosphere. Export is also influenced to some extent by changes in mercury input, although the response time is very slow. Other disturbances, such as change in land use, can create larger responses in a shorter time."

A. Yes.

Q. I'm sorry, I didn't quite catch that. Do you agree with that?
A. Yes.
Q. Thank you, I apologize. My hearing isn't what it used to be, Dr. Driscoll. It's not your fault.
A. Mine either.
Q. Now, Dr. Driscoll, I'm sure you're aware that at one point in time the Environmental Protection Agency issued a Clean Air Interstate Rule?
A. Yes.
Q. And the program under that -- that rule itself was vacated by court action.
A. Yes.
Q. And I'm assuming you're aware that prior to the time that the Clean Air Interstate Rule was vacated, that North Carolina adopted the approach of that rule.
A. Yes.
Q. And that under the terms of that rule, there would be a two-phased reduction in mercury emissions mandated.
A. Yes.
Q. Under a so-called cap-and-trade system.
A. Yes.
Q. And I believe I'm correct, Dr. Driscoll, in saying that you did not consider North Carolina's own contributions to mercury depositions in North Carolina.

A. I just focused on the TVA sources in my analysis, so that's correct.
Q. And in your -- both your report and your testimony, I believe there's no discussion or quantification of the significance of the amount of the mercury reductions from TVA projected by Dr. Staudt.
A. Could you repeat that question.
Q. I apologize, sir. That came out a little scrambled. I will admit that readily.
Dr. Staudt, as I think we've already had you testify to, projected a certain level of mercury reductions from TVA under his control plan.
A. Correct.
Q. Am I correct, sir, in stating that you didn't quantify exactly what that reduction would translate into in terms of TVA's mercury contributions to North Carolina?
A. I understand now. No, I did not.
Q. I appreciate your patience, sir.
You made a remark just a moment ago, did you call it, I think it was paleoecological evidence?
A. Paleoecological studies or palaeolimnological studies, yes, I did.
Q. I believe actually you've done some work with some information from those studies, have you not?
A. I have, yes.

Q. I believe, in fact, that there is a -- I think it was -- the information was obtained from some lakes in the Adirondacks?
A. I've done some work in the Adirondacks as well as other areas, yes, that's correct.
Q. Well, I would like to focus your attention, there's a study that I believe goes by the acronym of PIRLA, Paleoecological Investigation of Recent Lake Acidification.
A. Yes, that's correct.
Q. Am I correct in stating that you, perhaps in conjunction with one or more of your students, studied those cores in terms of the mercury levels that were revealed in them?
A. That's correct.
Q. And I believe that, if I'm correct, that you found that there was an uptick, my term, in mercury deposition in the Adirondack lakes that were subject to this coring in the time frame roughly 1900 to 1940.
A. Yes. There was a generally -- it appears that the levels of mercury deposition are fairly stable through the 1800s, and then starting around 1900 we saw systematic increases in mercury deposition across these -- across these lakes.
And I should add that we've seen that in other regions that have been published in other papers beyond that paper.
Q. I have no doubt of it, sir. But the question I'd like to address to you would be even in the wake of reductions in what

I'm going to call new mercury deposition, we still have a history of mercury deposition residing -- residing in the ecosystems as evidenced by these lake cores.

A. Correct. There is a legacy of mercury deposition which has been deposited. And actually, a critical research question that we are -- and others are wrestling with now is what's the fate of that legacy mercury? Is it permanently sequestered or has it become transported and ultimately available to fish, and that's an open question.

Q. So the question of whether this, as I think you -- I like that term legacy mercury -- whether that legacy mercury is going to be transported back into the natural system is an open one.

A. Right. Right. But one thing I might add to clarify the point here. We've -- not in the paper that you referred to but in subsequent papers, we've had the opportunity to relate these cores and we currently have done this with over 40 sites throughout the northeast, and we find very strong relationships between mercury deposit in the sediments and regional estimates of mercury emissions. So we think that these cores are really solid records of the historical trends in mercury.

Q. Thank you. Dr. Driscoll, if the science develops that this legacy mercury is transportable and is not sequestered, would you agree with me that at least one of the implications

of that would be even as we reduce the amount of mercury emissions and deposition, that the amount of mercury that will be available in the aquatic system for potential methylation may not, in fact, decline?

A. You're correct, but it's an open question and that's an area, as I said, of very active research; but I'm heartened by the patterns that we've seen in these recent cores that you allude to.

So one of the things you talked about, the uptick, as you referred to, of the mercury around 1900, but the values of mercury deposition actually peak in many of these sites in the '70s and '80s and have dropped down 20 or 30 percent in recent years, which is entirely consistent with regional emissions. And I'm very encouraged that the sediment record is showing these decreases in mercury deposition which are consistent with these records. So, so far it appears like it is reflecting those decreases in emissions and that's a positive sign.

But you're correct, that if this legacy mercury somehow would become mobilized, it would be a huge, huge problem.

Q. Very well, sir. You would acknowledge, would you not, that there are uncertainties inherent in the measurement of mercury deposition?

A. Sure. There's uncertainties in all scientific measurements.

Q. And that there is a normal year-to-year variation in mercury deposition.
A. Yes. There's a lot of year-to-year variation which is dependent on temperature and quantity of precipitation, climatic conditions, among other things. So yes, most definitely.
Q. So between the uncertainties in the measurement and the normal year-to-year variation, that would create what I'm going to call noise in the system in terms of trying to determine the effects of mercury deposition.
A. That -- yes, that's true.
Q. And I believe -- and forgive me. I'm more than a few years removed from the last chemistry course I took. I've been trying to study it very hard recently. But if I -- I think if I understood one of the implications of something you testified to, if you reduce mercury emissions by -- and this is just my term, let's say 10 units, that would not necessarily result in a 10 unit reduction in deposition. It would be something less than that, would it not?
A. Your question is not very well constrained. It's difficult to answer. It really depends on where you are in time and space and it's hard to -- it's hard to answer your question with much certainty.
But I can say one thing for sure. We know that by the first law of thermodynamics there's conservation of mass.

Matter cannot be created or destroyed. So if there's mercury that's released, it somehow has to go into the atmosphere and it has to be consistent with what was -- what was released. But there will be a lot of heterogeneity in time and space where that mercury is deposited for sure.

Q. I appreciate your critique, Dr. Driscoll. That's very helpful. Let me try and come back with a somewhat better crafted question to advance the process.

A. Okay.

Q. Let's say that if -- just taking a more concrete example. If a TVA plant reduces its mercury emissions by 10 units of mercury --

A. So you mean by units, you mean tons or whatever?

Q. Whatever unit.

A. Kilograms or something?

Q. Well, pounds.

A. Okay. Pounds, that's fine.

Q. Let's get more concrete and say that if a TVA plant reduced its mercury emissions by 10 pounds, that would not necessarily translate into a 10-pound reduction in deposition on North Carolina.

A. Yes, that is the case because mercury is going to be distributed variably across the landscape depending on the form that's emitted, the ambient conditions, whether there's precipitation events, what's the ozone content, what's the

chloride content in the atmosphere. There are a lot of processes that influence the chemical processes of mercury in the atmosphere and the deposition processes. So it varies depending on the conditions. So it's very hard to say without specific information.

Q. A fair answer, sir, and I thank you for it.

As promised, let's talk a little bit more about sulfate and mercury methylation. I think that you're quite correct in stating that because of the nature of the bacteria involved in the methylation process, because they are sulfate reducing bacteria, obviously sulfate has a role in that process. I think you would agree with me on that score.

A. Yes.

Q. I think you would also agree with me that sulfate is only one of a number of conditions that you have to have present for the methylation of mercury.

A. Yes, that's true.

Q. There has to be a particular temperature range, is that not one condition?

A. Yes.

Q. And there has to be a restricted supply of oxygen, correct?

A. Zero. Very restricted. No oxygen.

Q. I think that would qualify as very restricted.

There has to be an energy source of some type.

A. Principally organic carbon, that's correct.
Q. And the mercury has to be in a form that's accessible to the bacteria.
A. That's correct.
Q. So if one of these other conditions is lacking, the presence of sulfate will not produce methylmercury.
A. That is correct. So as we talked about, there are certain environments like sediments and wetlands where we -- where there is the lack of oxygen and the abundance of labile organic carbon or, as you termed it, an energy source that would allow this to go on. And of course, you would need mercury as well. So those are the environments where methylation generally would occur, yes.
Q. Thank you. I'll now try to return, perhaps unsuccessfully, to the days in the chemistry lab. But it's my understanding that sulfate reducing bacteria produce, as a byproduct of that, sulfide?
A. Hydrogen sulfide, that's correct, yes.
Q. Hydrogen sulfide.
A. Yes.
Q. And I'm correct in stating that the sulfide in the hydrogen sulfide bonds tightly with mercury, does it not?
A. It does.
Q. So that the methylation process has its own dampering mechanism, if you will.

A. It does. It does. But the -- so this is -- this is interesting. It's called the Goldilocks effect. So that if there are low levels of sulfate, that will stimulate methylation of mercury. But as you indicated, high levels of sulfate, then you can have production of sulfide which may inhibit or impede the formation of mercury -- not the mercury because the sulfide would bind up the mercury. But the levels -- there is some uncertainty in the literature at which at sulfate concentrations this Goldilocks, so-called Goldilocks effect occurs, but it's generally at much, much higher concentrations than we're talking about for sulfate here. So in that range it would generally be a stimulatory effect.

Q. All right, sir. Now, you talked with, I think, some eloquence about the role of bioaccumulation of mercury in the food chain.

A. Thank you.

Q. You're welcome. And I think that one of the -- at least one of the areas of historical concern, at least recent historical concern has been the bioaccumulation of mercury in fish tissue.

A. Yes.

Q. Which, of course, has led to the fish advisories that you alluded to in your testimony.

A. Yes.

Q. So one of the things that regulatory bodies look at is the amount of mercury in the -- in fish tissue.
A. Yes.
Q. You also testified to the efforts that are made to try and measure the amount of mercury in surface waters which is a rather more difficult proposition.
A. That is clearly correct, yes.
Q. Because of the low concentrations typically found in the water.
A. And the ease at which mercury can be contaminated in the collection analysis of samples. So you are correct, yes.
Q. Yes, sir. I believe you mentioned that that collection is done with people in suits and gloves.
A. Well, we don't usually use suits too much these days, but we clearly use gloves and we often process samples in a clean room where we have -- we restrict the air to tight standards to make sure that there is minimal risk of contamination by mercury. Indoor air has relatively high concentrations of mercury relative to outdoor air because there's mercury in paints and electrical fixtures and things like that.
Q. Are you aware, Dr. Driscoll, whether North Carolina's reductions in mercury emissions under the Clean Smokestacks Act have been enough to produce a measurable impact either in mercury levels in fish tissue or surface waters?
A. I'm not aware of time series data that are available for

North Carolina on fish mercury. They may exist, but I've not seen them. In fact, very few states have very good time series data for fish mercury so it's hard to know what the trends are.

Q. Dr. Driscoll, I'd like to turn your attention, if I can, to the general subject of acid deposition.

A. Sure.

Q. And we'll need to spend some time discussing that. If I heard you correctly, and please correct me if I didn't, I believe you said that the rate of acid deposition has, in fact, declined over the last 20 or 30 years.

A. Yes. Emissions of sulfur dioxide for the country peaked in 1973 and there's been a decline since that time.

Q. What about the oxides of nitrogen?

A. Nitrogen oxide have not decreased as much, but controls on electric utilities in recent years have resulted in some decreases in emissions. So the trend isn't as clear for sulfur dioxide because the controls were implemented later, but in recent years there is evidence that there has been decreases in emissions and we're starting to see the effects of that.

Q. And you've already had some testimony concerning acid neutralizing capacity and pH --

A. Yes.

Q. -- as measures of what's going on in a natural system.

A. Yes.
Q. And I believe you also are familiar with the term soil base saturation.
A. Yes.
Q. And that's another measure for potential effects of acid deposition in a natural system.
A. Well, maybe not so much effects, but sensitivity clearly.
Q. But using soil base saturation is a legitimate measuring tool as to what's going on with the soils.
A. Right. It helps clarify the acid base status of soils, that's correct.
Q. And again, as we were talking about mercury deposition, there are uncertainties in measurement of such things as the deposition of sulfate and nitrate into the natural system.
A. Yes.
Q. And that there is a year-to-year variation in the deposition of sulfate and nitrate.
A. Yes.
Q. Once again, creating some noise in the system in terms of measuring what's going on with acid deposition.
A. Yes, but if we have long-term records, then often those -- that year-to-year variation can be overcome, then we can see -- we can see trends like we've seen with the NADP network.
Q. Yes, sir, I understand that. But in terms of measuring

the impact of a particular reduction in acid deposition, the noise in the system in terms of measuring that impact could affect determining what that impact is.

A. Well, there's clearly year-to-year variability in deposition and there's clearly uncertainty in estimates of deposition.

Q. Dr. Driscoll, just to pursue this for a moment just to see if I can get some help from you on it. You described some systems as sensitive to acid deposition.

A. Yes.

Q. I'm just wondering if a more accurate statement would have been to ask to call them historically sensitive to acid deposition.

A. Yes, they're inherently sensitive. They're sensitive because of their native geologic and topographic features. That's -- those are the factors that drive the sensitivity. The bedrock geology, the topography, the elevation, the depth of soils, the quantity of water, the climate, all those things dictate their inherent sensitivity.

Q. Dr. Driscoll, you've had access to my conversation with Mr. Jackson very early in this trial. You may have seen something along the same lines that I'm about to pursue with you, but what I'm trying to understand is the term sensitive. Let me just try to explain to you what I mean by it and see if you agree with me.

When I hear the term sensitive, I'm thinking of a natural system in this case that would react to a fairly small change in conditions. In other words, it would be sensitive to a small increment of either increase or decrease, in this instance, acid deposition. And if the system is not going to be -- is not going to react measurably to a small increase or decrease in acid deposition, to my mind, sir, that isn't sensitive. Am I off base?

A. I'm not sure where you're going with this, but I think the -- a system could be sensitive and it could respond to a small increment or it could also respond to a large increment if we take the example of acidic deposition. So if a system is sensitive, its sensitivity, as I indicated earlier, is dictated by its inherent characteristics: Its base saturation, pools of exchangeable cations, calcium and magnesium, the minerals that are -- that make up the soil and the, you know, the climatic conditions, the hydrology and precipitation. So those -- those are generally thought to be the factors that dictate sensitivity.

But you could have a sensitive system in a pristine area that's not really receiving impacts of acidic deposition. You could have a sensitive system in an area that's receiving very high inputs. It's still going to be sensitive, but it will respond differently to the driver, I guess is what I'm saying.

So if that's consistent with what you're saying, then I

guess I agree with you. But I think it doesn't necessarily have to be a small change with respect to sensitivity. It could also have a large input -- could have a sensitive system which is experiencing a large input of acidic deposition as well.

Q. All right. Dr. Driscoll, that was an interesting response and I appreciate it.

A. You're welcome.

Q. Now, of course, you were relying on -- you were relying on the -- for part of your analysis, Dr. Staudt's projections for deposition under the, what I'm going to call the North Carolina control case for 2013.

A. I don't believe that Dr. Staudt provided me any deposition information.

Q. Well, did you receive that information from Sonoma Technologies?

A. The CMAQ deposition estimates were obtained from Sonoma Technologies, that's correct.

Q. All right, sir. Regardless of the source, you received information showing what North Carolina projected as the reductions in acid deposition, both sulfate and nitrate in 2013.

A. That's correct.

Q. And you would agree with me, would you not, sir, that you did not quantify the impact of those reductions in terms of

changes in the natural system by such measures as soil base saturation or acid neutralizing capacity.

A. No, I purposely -- I purposely didn't do that. My approach here was to try to focus on areas that had already shown demonstrable -- demonstrated impacts, so I didn't really address areas where there were -- things were less sensitive and things -- impacts might be more modest. So I focused on areas where there were clear impacts on soils and surface waters. So with that reasoning, any reduction in deposition would result in improvement of this already impaired system. So I decided there was no reason to do that, to try to quantify that because any reduction in deposition is going to result in an improvement in this impaired system.

Q. And you will agree with me, I'm sure, that soils compromised by acid deposition delay ecosystem recovery following decreases in emissions and atmospheric deposition of acidic substances.

A. Yeah, all scientific evidence suggests that that's the case.

Q. And soil acidification serves to extend the time needed for ecosystems to recover from acidic deposition.

A. Yes.

Q. And surface waters recovery is delayed in response to sulfur dioxide emission controls due to release of sulfate from acidified soils.

A. From soils that have retained sulfate do you mean, previously retained deposits of sulfate?

Q. Yes.

A. Yes, I would agree with that for sure.

Q. And then the depletion of nutrient cations, which I believe you discussed as base cations, the calcium, magnesium, potassium, that the depletion of those cations hinders the capacity of sensitive soils to recover.

A. Yes.

Q. And that recovery of sensitive lakes and streams throughout acid sensitive areas in the east is slow.

A. Yes.

Q. And you would agree that there's been a general lack of response in acid neutralizing capacity in southeastern streams in response to the decline in depositions of acid deposition.

A. Yes.

Q. And you would agree with me, would you not, that part of the reason for that slowness of response is that we're looking at a long history of acid deposition.

A. Yes. It's been going on for a hundred plus years for sure. It has a legacy. Just like we talked about the legacy of mercury, there's a legacy of acidic deposition. It's clearly impacted soils and delayed their ability to recover.

Q. In fact, you'd agree with me that the current levels for sensitive sites, we're talking many, many decades before we

see significant recoveries in chemical indicators that we would expect to lead to improvement in biological resources.

A. Again, that's a fairly general question and it really varies from system to system. So if you have a system that has been -- has a modest value of acid neutralizing capacity and there are reductions in inputs, there may be -- there may be opportunity for recovery.

So for example, I think I mentioned previously that I do a lot of work in the Adirondacks and we have been tracking fish resources in response to improvements in water quality. So the systems that have positive but low values of acid neutralizing capacity, those sites are starting to see increases in acid neutralizing capacity and decreases in aluminum. And we are seeing improvements in fish diversity and individual species that were sensitive and were -- had left the system and have now come back.

However, for systems that are chronically acidic, that are very sensitive, highly impacted, even though we've had pretty significant reductions in acidic deposition, those levels of improvement have not been adequate to recover the fishery. They remain chronically acidic and are not able to support a fishery.

So it varies depending on the resource. Some resources are impacted less severely than others and those resources that are impacted the least will recover first and then the

ones that are most sensitive and are impacted the most may take a very long time to recover.

Q. And I believe by your testimony, some of the areas that have been impacted the most are the areas that we've been talking about here in North Carolina.

A. Yes, there have been some areas that have been heavily impacted, particulary in the high elevation stands near here, yes.

Q. But again, just so it is clear in the record, that for sensitive sites, we are talking many, many decades before we would see significant recoveries in chemical indicators that we would expect to lead to improvement in biological resources.

A. Yeah. Again, this is not a very focused question, but maybe you can try to help clarify it.

I think what we see across the northeast is that we see that there have been some reductions in acidic deposition and we're starting to see, at least in the northeast, less so in the southeast, surface water recovery. But we are still continuing to see soil acidification. So I think that the current levels of acidic deposition are still too high to basically offset this depletion of calcium that we've talked about. And until that occurs, we're not going to see substantial recovery, and that's going to require additional reductions in deposition.

So the bottom line, in the northeast and the southeast, soils are continuing to acidify. The current levels of acidic deposition are too high and those soils are showing net leaching, net loss of calcium and magnesium, and that is going to impair the long-term recovery of the system. So we have to get deposition down to a level that allows these soils to start to maintain their base resources.

Q. And that will take -- that's a process that will take many, many decades.

A. Depends on the emission reductions. The greater the emission reductions, the faster it will occur. So if there are controls that will jump start the process and -- but at current levels it's not adequate. If there are no controls on deposition, it will never happen.

Q. Well, Dr. Driscoll, I'm afraid I'm going to have to try to refresh your recollection on some things you've said in the past.

A. Sure.

Q. Do you recall attending a conference in May of 2001 entitled Acid Rain: Are the Problems Solved?

A. I probably did. I go to a lot of meetings. I'm sure if you say I did, I did.

Q. Well, let me represent to you that you were one of the prominent participants at that conference. In fact, your part of the conference was testimony before one of the

Congressional committees I think you alluded to in your direct examination.

A. Okay, yes. Uh-huh.

Q. And I would be correct in saying that you were quoted and, in fact, stated in your own submission to the conference that "at the current levels of -- for sensitive sites, we are talking many, many decades before we would see significant recoveries in chemical indicators that we would expect to lead to improvement in biological resources."

A. Yes, at current levels the rate of recovery is very slow and there's no doubt about that.

Q. There was a question and answer session and you received a question from a Patricia Bradt of Muhlenberg College, and that's B-r-a-d-t. And she asked you, "How do you anticipate a recovery of the calcium and the magnesium base lines in soil? Do you think that is going to happen? Is it going to leach in from the bedrock?"

And Mr. Driscoll, they didn't get your title correct. "It is a very slow process. These soils have been developing over 14,000, 15,000 years. They're very low in bases to start with because of the nature of the mineralogy. To redevelop those base cations will take a very long period of time. That is a large part of the reason why we expect recovery to be so slow."

A. Yes. I stand by that.

Q. And I believe that you testified on your direct examination that some of the soils we're dealing with here in the southeast are many hundreds of thousands of years old.
A. Much, much older, correct.
Q. Correct?
A. Yes.
Q. And are, in fact, very base poor to be -- were very base poor to begin with.
A. And more so than the northeast, correct, yes.

MR. FINE: Your Honor, I'm not sure how much longer you wish to go this evening. I'm afraid I do have some more questions for this witness.

THE COURT: Do you think you would go past 6:30?

MR. FINE: Your Honor, in all candor, I do not believe I would.

THE COURT: Don't think you will go past 6:30?

MR. FINE: No, sir, I think I can wrap it up before 6:30.

THE COURT: If we can do that, I think it might be good to finish this witness today and we'll have a fresh start tomorrow.

MR. FINE: Your Honor, I couldn't agree more and I will proceed with that goal in mind.

THE COURT: All right. Thank you. We'll just do that and that will turn you loose, then, doctor.

THE WITNESS: Very good, sir.

BY MR. FINE:

Q. Dr. Driscoll, of course, I'm sure that you are aware of the reductions that North Carolina either has achieved or is scheduled to achieve in sulfate and nitrate under the Clean Smokestacks Act.

A. Yes.

Q. And I should say more accurately, then, the emissions of sulfur dioxide and the emission of oxides of nitrogen which get converted to sulfate and nitrate.

Have those reductions been enough to produce a measurable impact, a measurable improvement in such measures, chemical measures as soil base saturation and acid neutralizing capacity?

A. Well, those measures are relatively recent measures and there are -- as I said in my testimony, the -- there are 12 sites in the southeast where there have been long-term measurements of the calcium status of soils. And most of those sites, the vast majority of those sites show net calcium depletion.

The -- that study was published a few years ago and I've not seen any updates. So I can't say that I've seen any scientific literature to suggest that there's been an arresting of the -- of soil acidification. So it's difficult for me to answer what the effects of recent controls are in

terms of soil acidification.

Q. If I can boil that down, Dr. Driscoll, you don't know.

A. I don't know, right.

Q. I'd like to return, if I can, briefly to the study of the cores that were produced by the Paleoecological Investigation of Recent Lake Acidification.

A. Sure.

Q. And I think you -- I think there were some 12 lakes that were subject to the coring.

A. Are you referring to the Lorey and Driscoll paper?

Q. In all candor, I'm not sure which paper I am referring to.

A. Okay. Well, in that paper, what you had talked to about earlier, the PIRLA study --

Q. Yes, the PIRLA study, yes.

A. There were eight cores.

Q. There were eight cores.

A. Yes.

Q. I sit corrected.

And I would be correct in saying in terms of acid deposition, those cores indicated that the lakes acidified sometime between 1920 and 1970.

A. Okay. So you're not referring to my mercury work. You're referring to other studies from the -- other papers from the PIRLA study that I wasn't involved with.

Q. I'm afraid that I am, sir. I apologize if I was unclear.
A. Okay. So indeed, there may have been 12, I don't know. I just know I was able to get aliquots of samples from some cores and it may have been a subset of a total. I'm sure you're correct, it may have been 12.
Q. Well, let me back up because we may be able to truncate this rather quickly.
Are you familiar with these other studies in terms of looking at the lake cores in terms of acidification of the lakes?
A. The diatom studies, yes. The PIRLA and diatom, d-i-a-t-o-m, studies. PIRLA, which stands for Paleoecological Reconstruction of Recent Lake Acidification, if I'm not mistaken.
Q. That is -- that's correct, sir.
A. Okay.
Q. So you are familiar with that study.
A. I am, although I wasn't involved in it.
Q. Thank you. And that study indicated that those lakes, the lakes that were studied, acidified somewhere between 1920 and 1970?
A. Yes. It varied from lake to lake, but I believe that was the range in which they, yes, showed changes in pH.
Q. In fact, at least for some of these lakes, that you did an experiment with reversing the acidification of the lakes.

A. You mean liming?

Q. Yes.

A. Yes, we've done liming studies.

Q. And that the lakes, in fact, that you limed you were successful in reversing the acidification, but only temporarily, correct?

A. Yes. So one thing about the Adirondacks, there's a large number of lakes in the Adirondacks, about 3,000, but they generally have very short residence times; and what I mean by that is the amount of time a molecule of water is within the lake. They typically flush in a few months, weeks to months. So when you add a chemical to neutralize the acidity, it gets flushed out with the water itself. So some of those effects are short lived.

Q. And so the lakes, in fact, after a fairly short time, as you say, reacidify.

A. Some of them, yes.

Q. Would I be correct in stating that's reflective of the levels of sulfate that were in the soils that would be -- would leach into the water systems to reacidify them?

A. I think it was more of a calcium issue. I think that the treatments didn't really show major changes in sulfate. The material that was added was limestone calcium carbonate. It neutralized the acidity. As you said, the neutralization was short lived. The lake was -- the acid neutralizing capacity

basically resumed low values once that lime was flushed out.

I should add that we also did studies where we added lime to the soil and we continued to monitor those sites and the water quality remains high, and that was done in the late 1980s. So now we're talking 20 years that the acidity has been neutralized when the lime has been added to the soil.

Q. Well, what is your theory as to why the lake reacidified after the calcium was flushed?

A. Because the acid water continued to come in from the streams and precipitation and flushed out the added lime and it just resumed its previous state.

Q. So in your view, the level of sulfate or nitrate in the soil had no role in the reacidification of the lakes?

A. Well, there are high levels of sulfate, but they were before and after the treatment. I don't think there were any statistically significant changes in sulfate or nitrate following those lake liming treatments, if I recall. I mean, those were a few years ago, but my recollection was that there weren't any changes.

Q. Well, wouldn't the sulfate leaching in from the soil contribute to the reacidification of the lakes?

A. It was more -- as I said, it was more the base. Over the short term we added a large amount of base to neutralize the acidity. Once that was flushed out, the acidity resumed which was dominated by the sulfate and nitrate. But those levels

were high before, during and after the treatment.

Q. Just a couple other areas, Dr. Driscoll --

A. Sure.

Q. -- and then I'll be able to turn you loose. I appreciate very much your patience this afternoon.

A. No problem.

Q. First of all, I'd like to direct your attention to the document that I think your attorney -- the attorney for North Carolina, I should say, placed in front of you. It should be in your book, Plaintiff's Exhibit 344.

A. Yes, I've got it.

Q. I understand, of course, that this is a fairly small map, but if you could help me, I'd appreciate it. I notice that most of the red and yellow circles that show up in the green area are in the areas actually north of North Carolina. Am I correct?

A. It looks like that. A lot in Virginia and West Virginia, but there are some in -- it's hard for me to actually see the state boundary here on this map in this light. But there are some yellow throughout the green, you know -- there are -- I could count them up for you, but there -- I mean, I think you're right that there's more up north than in south.

But I wasn't involved in the SAMI so I believe these are SAMI -- SAMI data or data that were used for SAMI. My understanding, although I wasn't part of SAMI, is that the --

this is a map of the SAMI region. The green represents the siliciclastic deposits and the yellow and orange are streams that have either chronically acidic or low values of acid neutralizing capacity. I think the point is that they approximately correspond with the locations of these siliciclastic bedrock.

Q. Well, just so that we're clear, though, that the -- most of the -- as you can see on the exhibit, that most of the red and yellow circles are, in fact, outside what appears to be the state of North Carolina; is that correct?

A. Yes.

Q. In fact, I only see one red circle that may be in the state of North Carolina.

A. Yes, I think you're right.

Q. All right, sir.

Q. Heading to the finish line.

A. Pardon me?

Q. Heading toward the finish line.

A. Okay.

Q. You, I think, mentioned that you're familiar with modeling, though you're not an atmospheric modeler, but you have participated in a model of trying to measure or predict ecosystem responses, have you not?

A. Yes.

Q. And I believe that -- and help me with with this,

Dr. Driscoll, I believe the name is PnET-BGC.
A. PnET, yes.
Q. And if you can please translate that acronym for us.
A. The acronym stands for Photosynthesis Net Evapotranspiration. Big P, little n, big E, big T. And the BGC stands for biogeochemistry.
So what this model does is it depicts all the chemicals that we've been talking about, calcium, magnesium, aluminum, sulfur within vegetation, soil and water within a watershed. Basically trying to depict the acid base transformations that occur in forest and watersheds.
Q. I'd be correct in saying that you were -- let me back up and ask this other question. I'm correct in saying that you participated in the development of this model?
A. Yes.
Q. And that you participated in a study where this model was used using data from the northeastern United States.
A. Yes.
Q. And I'm correct in saying that the model -- that the PnET-BGC model projected only modest improvements in soil base saturation and acid neutralizing capacity in response to reductions much larger that the reductions we're looking at here.
A. It's hard to translate, but I would say you're correct, yeah. Yeah.

MR. FINE: Your Honor, that's all the questions I have.

MR. GOODSTEIN: I have one, Your Honor.

THE COURT: All right.

REDIRECT EXAMINATION

BY MR. GOODSTEIN:

Q. Dr. Driscoll, is it your view that delay in soil recovery time is a reason not to reduce acid deposition now?

A. No, quite the opposite. I think we need to -- you know, if we want -- there are benefits associated with recovery and so I think the sooner that there are emission controls, the sooner there will be -- there will be recovery. And there are lags built into the recovery of all ecosystems, and again, it varies across different ecosystems. But the sooner there are emission controls, the sooner there will be reductions and sooner there will be recovery.

MR. GOODSTEIN: No further questions, Your Honor.

MR. FINE: Nothing further, Your Honor.

THE COURT: Gentlemen, I congratulate you both.

All right. We'll take a recess until tomorrow morning at 9 o'clock.

Thank you, Dr. Driscoll.

(Evening recess 5:20 p.m.)

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF NORTH CAROLINA
CERTIFICATE OF REPORTER

I certify that the foregoing transcript is a true and correct transcript from the record of proceedings in the above-entitled matter.

Dated this 21st day of July, 2008.

s/Cheryl A. Nuccio
Cheryl A. Nuccio, RMR-CRR
Official Court Reporter